ROADS AND STREETS

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All-Welded Mobile Equipment *for Road Surfacing Operations*

By Jos. C. Coyle

TAKING a tip from the well known mobility of a circus organization, C. V. Hallenbeck, a Denver, Colo., contractor, has perfected a group of units for preparation of road surfacing materials which may be transported from job to job at high speed and wheeled into place, ready for operation, in a very short time once they are on location. From raw aggregate storage to the finished pre-mix, loaded in trucks for distribution, the surfacing materials are handled mechanically by a series of machines mounted on wheels and spotted for a continual flow of material.

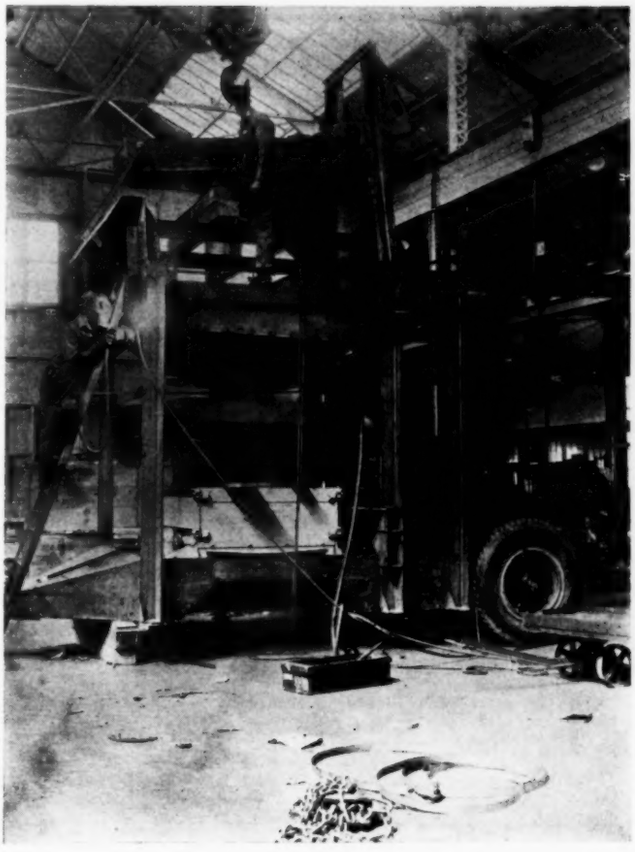
A portable conveyor delivers the raw aggregates to a drying unit; another conveyor, or elevator, carries it from the dryer up into a 3,000-lb. pre-mix plant, where it is screened, proportioned, mixed with the proper amount of oil and carried by another portable conveyor to the truck. A horizontal boiler, mounted on a truck chassis, furnishes steam and road oil is stored in an elevated tank which is designed for moving on a trailer. A power plant for generating electricity, and other small units are mounted on skids so as to be quickly loaded on trucks when ready to move and easy to place when on the job.

All important features of the machines have been patented by the contractor. The units were constructed largely by electric welding, according to specifications and by Hallenbeck's mechanical engineer, A. Hack. Welded construction was selected because of its resistance to vibration induced by road travel.

The specially constructed trailer for transportation of power shovels and other heavy equipment weighs approximately 10,000 lbs. It has four heavy balloon tired wheels at the rear, and is supported in front, when on the road, in a strong hitch, of welded steel construction, beneath the rear axle of a truck. Loading a power shovel with the dipper resting in the rear end of the truck the weight of shovel, truck and trailer is evenly distributed on the ten wheels of truck and trailer.

The low platform of the trailer is supported by four 8-in. eye beams, which project far enough behind it to carry the four wheels. Axles are 3½ by 3½ in. steel and each wheel has a pair of heavy springs and four overload springs. Forward spring shackles are supported by a welded structure of 1 in. steel, welded to the top of an 8-in. I-beam at the rear of the platform by a heavy bead. The I-beam and shackles are braced with curved sections of 1 by 4 steel, welded to the main beams of the trailer and to the shackle structure.

Rear spring shackles are of 1 by 4 in. steel, welded, and with bushing in a built up steel structure at the end of each main beam. The beam ends are covered with a bumper of 1 by 8 in. steel welded to them. The

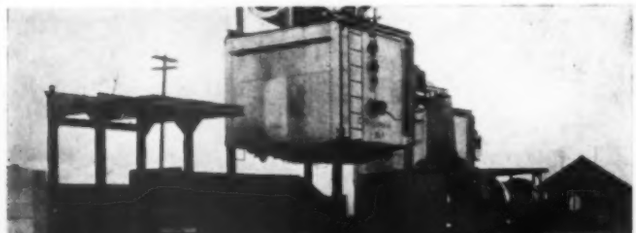


Pre-Mix Unit Under Construction

heavy springs are inclosed at front and rear between vertical guides of welded 1 by 4 in. steel, braced with welded inserts. The guides are welded to the main beams. The triangular front end of the trailer is housed with welded steel plates, reinforced by four sections of ¾-in. steel plate, welded to the top and bottom housing and converging in the square shaped housing of the tongue. The top and bottom plates of the latter are welded together at the end into a hitch plate shaped like a beaver's tail. In inserting the reinforcing plates mentioned the edges were first beveled, so as to form a vee type joint for welding, thus strengthening the joints. The steel housing at the sides extends to the rear end of the trailer and are welded to angles at top and bottom corners.

The pre-mix unit is mounted on a steel chassis very similar to the one just described, except that the main

beams are somewhat lighter and a section of the side housing is cut away to provide clearance for the elevator which carries the hot mix to the trucks. At front and rear the sides of the chassis are stiffened by channels welded to the inner surface of the side plates. Wheel mounting and tongue construction is practically the same as on the trailer.



Rear View of Trailer

A 3,000-lb. pug mill type mixer is mounted on the main beams of the machine. The dump gates of the mixer is operated with a steam cylinder which projects forward into the tongue housing. Welded steel supply bins and batching hoppers are supported above the mixer by 4 by 4 in. angles welded to the sides of the chassis. Heavy vertical H-beams at the rear of the machine support a large fly wheel and other driving gears. A small shaker screen is mounted above the hoppers on uprights of channels and angles having a sheet of steel welded to the two rear members. This sheet is stiffened just back of the screen by a large section of channel welded to its outer surface, so as to resist vibration and support the housed gears which drive the screen. The entire frame of the machine above the hoppers is hinged to the lower portion so as to drop flat when on the move, to clear low bridges, tunnels, etc. The operator of the machine stands on a hinged wood platform at the side of the machine.

The unit for drying aggregates has a 54-in. by 18-ft. rotating shell of 5/16 steel, mounted on cast iron tires bridged 6 in. off the surface of the shell to avoid distortion by heat. The tires move on ball bearing dust sealed trunnions. The shell was assembled by welding, the edges of all plates being beveled for a vee-type joint. Frequent moves while welding prevented distortion of the plates from too much heat. Fillets were left slightly below the level of the plates, so as to give a perfect bearing to bands of ¼ by 5 in. steel which were welded over the round seams, with a bead at each edge of the bands. Eight lifting angles were attached to the inner surface of the shell by special means which allows for expansion without distortion of the shell.

Inside the shell is a fire tube of heat resisting alloy steel, supported by bars of the same material. This tube is 3/16 thick and 12 in. in diameter, flaring at the front end to a diameter of 18 in. A number of triangular openings 8 in. long were punched, and caps 12 in. long, and opening towards the front, welded over them, to properly distribute the heat. The refractory nature of the metal used necessitated punching the holes instead of using a cutting torch.

For the same reason the tube was made in two sections, formed in a brake and finally shaped about a section of pipe in a press, where the edges were welded together, using a rod of special composition. The two sections were then welded end to end. Vee type joints were used and acetylene welding.

The framework of channels, angles and heavy pipe, which support the dryer are all welded, the bottom members of 8 by 8 in. angles resting on a double thickness of belting placed on top of the truck chassis. The chassis was lengthened to 247 in. wheel base and the forward two thirds reinforced by riveting ⅜ in. plate to the chassis.

The Dryer Unit

The Boiler Unit

When the dryer is in operation a conveyor delivers the aggregates to a welded steel hopper of No. 10 gage ¼ in. steel at the front end of the shell. Just back of this hopper are a pair of fans, with welded housing and a 6 ft. stack of ⅛ in. welded stel, to provide draft. Fire is introduced to the fire tube by an oil burner, patented by the contractor, the oil being atomized by live steam at 150 lb. pressure, from a portable boiler. The draft is regulated with dampers operated by levers at either side of the machine. A welded steel hopper at the rail end of the machine takes the aggregates to the boot of an elevator which delivers them to the pre-mix plant mentioned. The machine is equipped with ball bearings throughout, thus reducing the amount of power necessary

and allowing it to be driven entirely by a power take-off from the truck engine. A vee belt drive is used to a shaft at the side of the machine, which distributes the power to various auxiliary units.

The boiler which furnishes steam to a set is mounted on a truck chassis, and carries the lower 10 ft. joint of the smokestack hinged to the boiler and dropped to horizontal position over the driver's seat, supported by two curved sections of channel, welded to the boiler shell. The two other sections of the stack are carried on channel steel supports which project at each side of the chassis. To erect the stack the three sections are bolted together and the third member of a tripod frame is bolted to the lower section near the top, with tripod in vertical position, the foot of the double members being hinged to the front end of the boiler. The tripod is then used to pull the stack erect, by drawing the top end of the double members back and anchoring near the steam dome. The single member then forms a brace for the stack. 75 gal. reserve tanks for water and fuel are installed beneath the boiler, and pumps are carried on the side.

Welded steel truck bodies are used by this contractor. One truck carries both acetylene and electric welding equipment for field work and trained welders in the contractor's employ make practically all repairs to equipment.

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Status of Public Works

Highway Construction

THE estimated cost of the highway work under construction on Dec. 30 under the $400,000,000 appropriation of the National Industrial Recovery Act was $159,575,000.

Awards of 4,494 projects at an estimated total cost amounting to $232,490,000 had been made out of a total of 5,287 projects advertised for contract or to be constructed by State forces involving an estimated total expenditure of $273,849,000.

On Dec. 30, there were 129,346 men employed on public works highways under construction on 2,752 projects with funds from the Federal Public Works appropriation provided for in Section 204 of the National Industrial Recovery Act.

There were 476 projects, involving a total expenditure of $11,772,000 reported by the Bureau of Public Roads as completed on Dec. 30. Of these 46 were completed during the week ending December 30, 1933.

Kansas had awarded 100 per cent of the public works highway funds provided for in Section 204 of the National Industrial Recovery Act in projects ready to begin or started by contract or day labor.

In the whole country, work advertised for contract or started by day labor employed directly by the highway authorities involved 63.9 per cent of the $400,000,000 provided for public works highways under Section 204 of the National Industrial Recovery Act.

Of the total apportionment of $394,000,000 of public works funds, $186,651,646 was allotted to Class I projects (projects on the Federal Aid highway system outside of municipalities), $112,771,667 to Class II projects (projects on extensions of the Federal Aid highway system into and through municipalities, and $94,676,687 to Class III projects (projects on secondary or feeder roads). The status of these classes on Nov. 30 was as follows:

	Class I	Class II	Class III
Completed:			
Total cost	$3,738,967	$912,593	$293,737
Public Works Funds	3,591,331	904,092	288,118
Regular Federal Aid.	60,958	.....	.....
Mileage	686	40.2	38.7
Under Construction:			
Est. total cost	$89,237,818	$19,845,909	$25,407,668
Public Works Funds Allotted	81,097,525	19,106,872	24,447,656
Regular Federal Aid Allotted	4,715,463	335,091	.....
Percentage completed	22.8	20	14.5
Mileage	5,450	346	3,018
Approval for Construction:			
Public Works Funds Allotted	$38,683,505	$18,154,212	$19,781,273
Mileage	2,287	333	2,127
Balance of Public Works Funds Available for New Construction	$63,179,285	$74,606,491	$50,159,640

TABLE I—SUMMARY BY TYPES OF CONSTRUCTION

Types	—NRH Projects— Estimated total cost	Miles	—NRM Projects— Estimated total cost	Miles	—NRS Projects— Estimated total cost	Miles	——Total—— Estimated total cost	Miles
Graded and Drained	$16,436,635	2,113.2	$1,923,892	80.6	$8,054,872	1,347.1	$26,415,399	3,540.9
Sand Clay—								
Untreated	779,556	208.9	53,714	7.8	768,743	214.9	1,602,013	431.6
Treated	1,717,510	252.1	77,547	11.4	1,317,789	183.3	3,112,846	446.8
Gravel—								
Untreated	15,230,988	1,778.6	588,691	63.9	10,163,569	1,849.7	25,983,248	3,692.2
Treated	3,477,088	366.7	316,960	24.8	6,913,842	787.5	10,707,890	1,179.0
Macadam—								
Untreated	1,156,960	53.0	95,746	4.1	352,621	57 2	1,605,327	114.3
Treated	1,608,736	84.5	170,755	4.7	1,038,346	60.5	2,817,837	149.7
Low Cost Bituminous Mix	11,018,293	1,336.4	592,892	42.0	2,057,970	224.2	13,669,155	1,602.6
Bituminous Macadam	5,535,114	238.0	1,320,402	27.9	1,624,615	124.7	8,480,131	390.6
Bituminous Concrete	7,548,380	303.3	8,414,307	113.0	2,060,330	137.3	18,023,017	553.6
Portland Cement Concrete	52,769,915	1,620.3	17,006,509	310.4	6,714,412	182.0	76,490,836	2,112.7
Block	1,516,384	26.1	1,629,551	20.8	352,300	5.0	3,498,235	51.9
Bridges and Approaches	15,453,280	35.0 (1,318)	5,642,333	5.5 (159)	4,844,980	9.3 (400)	25,940,593	49.8 (1877)
Grade Separations—Railroad, Highway	2,198,651	6.7 (66)	1,392,157	2.2 (24)	411,893	1.1 (10)	4,002,701	10.0 (100)
Grade Separations Between Highways	47,359	.2 (1)	241,422	.3 (4)	.....	.....	288,781	.5 (5)
Miscellaneous	81,750	....	19,421	....	17,900	.....	119,071	....
Total	$136,576,599	8,423.0	$39,486,299	719.4	$46,694,182	5,183.8	$222,757,080	14,326.2

Note.—The figures in parentheses indicate the number of structures.

New Developments in the Production and the Use of Paving Brick

By G. F. SCHLESINGER
Chief Engineer and Managing Director National Paving Brick Association

BRICK as a burnt clay product has been used for paving since the earliest period of recorded civilization. There is authentic proof that the streets of Babylon during the reign of Nebuchadnezzar were paved with "burnt bricks" and there is existing evidence that the brick roads built in Holland during Napoleon's time are still in service today. In this country the first brick pavement was laid in Charleston, W. Va., in 1871, and gave satisfactory service for 38 years. Brick almost immediately became a popular type for surfacing municipal streets and has continued to be utilized extensively during the changing traffic conditions of the last 60 years.

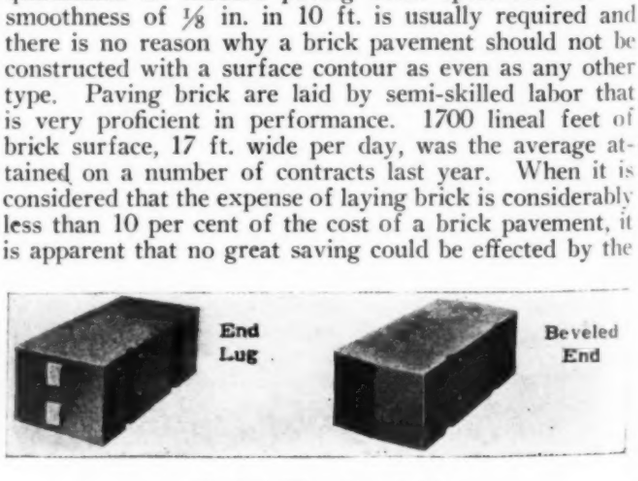
Surface Removal Method for Excess Asphalt Filler in Operation on Pearl Road, Cleveland

Recent years have witnessed important developments in the utilization and in the manufacture of paving brick. It might first be desirable to review briefly the design of the modern brick pavement as compared with the construction methods of the early days.

Old and New Methods Compared.—The first brick pavements were usually either laid directly on the excavated subgrade or on a leveling course of gravel or crushed stone. Of course, such construction was inadequate for the traffic that they were required to carry. The surface contour was never smooth and, because of the lasting qualities of the brick pavement units, they became more irregular as time elapsed and traffic increased. Nevertheless, the service given by brick pavements thirty or more years old, in practically every city in the United States, has been truly remarkable. The foundation for the modern brick pavement is, in most instances, concrete although there are many projects where the flexible type has been very satisfactory. The smoothness requirements for the surface finish of base courses of all kinds in modern specifications is practically the same as for the surface of the pavement. There is some difference of opinion among engineers whether a concrete rich in cement content should be used or one that is lean. Judged by existing practice, especially among municipal engineers, the leaner concrete is favored. Reinforcing has been used in some instances and also pre-located and controlled expansion and contraction joints.

In the early practice the bedding course (cushion) varied in thickness to take care of the irregularities and rough finish of the base. This frequently resulted in a shifting of the cushion with subsequent effect on the brick surface. A present day brick pavement is designed with a much thinner cushion course than was used formerly and is of uniform thickness. A uniform depth of not more than ¾ in. is possible because modern specifications require a smooth base course. Formerly, plain sand was the universal material for the cushion but a development of recent years is the use of a bituminous sand mastic mixture. This type of cushion has the advantages of being water-proof and stable and of having considerable ability to bridge over cracks in the base. Granulated slag, where available economically, is an excellent material and a cement-sand mixture has also been used but is not recommended.

The depth of the brick course itself in modern design is less than was formerly used. Investigations and experience have shown that, when properly supported, brick down to 2½ ins. in depth will withstand heavy traffic. A depth of 3 ins. is in most common use except in the West where 2½ ins. is the practice. The brick are now laid with the shortest dimension vertical (flat wise) which had produced a more satisfactory riding surface and has decreased the cost. At first, most of the brick were of the repressed variety with lugs and a minimum thickness of 4 ins. Later, the wire-cut vertical fiber (lugless) brick came into extensive use especially in the West. In recent years, the trend is again toward the increased use of lug type of brick which subject will be discussed later in the paper. The workmanship on laying brick has been improved materially with the higher requirements of modern paving brick specifications. A smoothness of ⅛ in. in 10 ft. is usually required and there is no reason why a brick pavement should not be constructed with a surface contour as even as any other type. Paving brick are laid by semi-skilled labor that is very proficient in performance. 1700 lineal feet of brick surface, 17 ft. wide per day, was the average attained on a number of contracts last year. When it is considered that the expense of laying brick is considerably less than 10 per cent of the cost of a brick pavement, it is apparent that no great saving could be effected by the



Vertical Fiber Lug Brick

mechanization of this construction operation. Men can be given jobs without sacrificing speed, quality or economy.

The filler now being used in practically all brick paving construction is a bituminous material which, in a great majority of cases, is straight asphalt. Formerly cement grout was recommended and used extensively but, with the flexible type, difficulties incident to temperature changes, such as internal stresses and occasional blow-ups have been eliminated. A good bituminous filler, if properly applied, seals the joints against the entrance of moisture and protects the edges of the brick. It should

Construction of 30 Ft. Wide Pavement on Liberty Highway F A 601, Olean, N. Y.

penetrate the joints when applied at high temperatures and retain sufficient flexibility at freezing temperatures. It should be of a consistency that will not permit it to flow out or bleed in hot weather, nor chip out in cold weather. It should adhere to the sides of the brick, and, at the same time, should not be so adhesive that it will not wear off the surface under traffic. Such an asphalt is required to meet rather rigid specification limits but is readily available on the market. Even with an ideal filler, the results will be unsatisfactory, if there is poor workmanship in its application. Sufficient heating before application, minimum thickness of the surplus asphalt on top, and thorough incorporation of the grit cover material immediately, will produce the correct results. A more recent development in filler application will be discussed later in the paper.

Most Recent Developments.—Three developments in the use and manufacture of paving brick that have taken place in the last three years promise to be of major importance in improving the quality of the brick type of paving. While there probably has not been sufficient experience to fully evaluate the merits of all these innovations it can be said that there is ample cause to believe that the ultimate outcome will be a surface course of increased strength, durability, safety and economy. The developments referred to are, (1) the vertical fiber lug type of paving brick, (2) the surface removal method of filler application, and (3) the de-airing process of paving brick manufacture. They will be discussed in order.

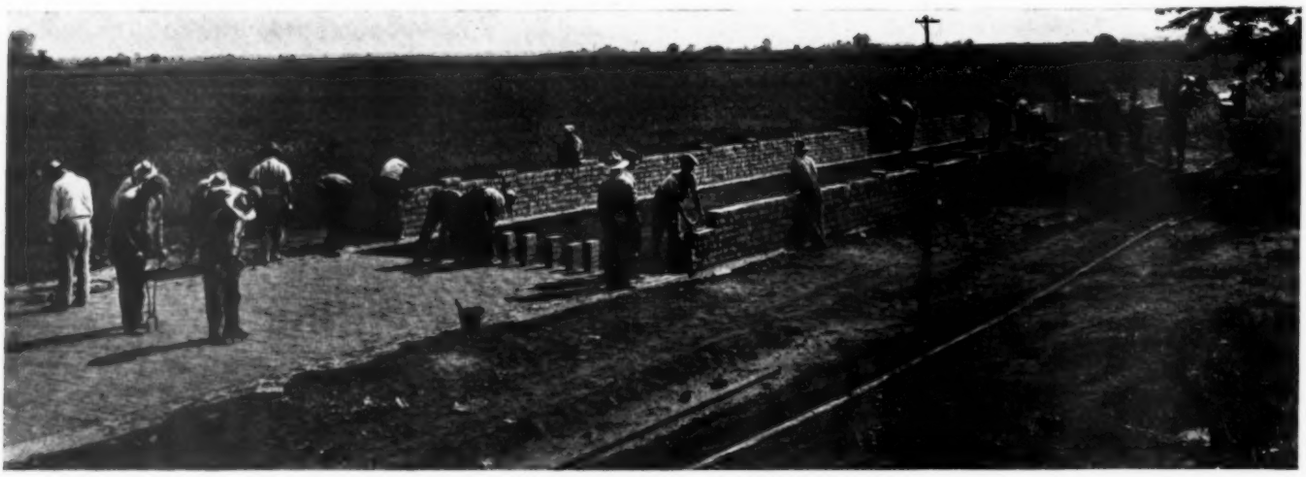
Engineers for years have realized the desirability of having the wire cut face of the brick in the surface of the pavement. When it became the practice to lay wire cut brick flatwise, in addition to the decreased depth, a more non-skid and smoother pavement was secured. Proper lugs on the sides and ends of the brick insure thorough penetration of the filler and complete sealing of the joints. Until about two years ago there was no commercially practical method of manufacturing vertical fiber brick with the proper type of lug. The problem has now been solved and the vertical fiber lug brick is in almost universal use in some sections. Four lugs on the side of the brick covering a maximum area of 2½ sq. ins. permit the free flow of filler and will break down under stress due to temperature changes or other causes. This satisfies the requirements of an ideal lug—acting as a temporary spacer until the filler is applied. With the universal adoption of the vertical fiber lug brick there is no reason why the sizes and types of paving brick can not be reduced to three—having the same surface dimensions, with varying thicknesses.

Last year witnessed a great increase in the practice of completely removing the excess filler from the surface of the brick at the time of construction. This is accomplished by moistening the surface and scraping off the asphalt immediately following the squeegeeing. The asphalt removed is not wasted but used again after being re-heated. Due to the decreased quantity of filler required and the elimination of the necessity of incorporation grit in the surface it is apparent that there should be no increased cost involved. Various materials have been used as the coating fluid, including whitewash, B. and B. adhesion preventing fluid (proprietary), and a calcium chloride solution. The coating materials have been applied in various manners such as by means of brushes, rollers and pressure sprays. The use of a 35 per cent solution of calcium chloride with a 1 per cent starch content is the latest development and experience indicates that it is well adapted for this method. It has been applied under pressure through a nozzle that produced a fine fog-like spray which moistened the surface only, with no leakage into the joints. While it would seem to be desirable to prevent moistening the sides of the brick, experiments indicate that the prevention of adhesion is a temporary effect. The excess filler is readily removed by hand with straightened-out hoes or similar cutting tools. No particular care is necessary to secure a thin coat of asphalt on the surface and, as a matter of fact, a rather heavy cost facilitates the removal operation. The immediate result is a clean brick pavement, with flush well filled joints, and if the brick are the wire-cut

Columbus-Lancaster Road in Ohio, Completed in 1933. Asphalt Filler Has Been Removed from Surface

vertical fiber type, there is no question about the non-skid qualities of the surface.

The idea of de-airing clay or shale in process of manufacture, is not new, and as early as 1902 a patent was issued on an evacuating process for producing stiff mud clay products. Commercial application was prevented principally due to the impossibility of securing a rugged



A Resurfacing Job in Illinois

and efficient vacuum pump that would consistently produce and maintain a very high vacuum. There are now several types of commercially successful vacuum extrusion brick making machines on the market. The clay as it comes from pug mill must be cut or shredded into small pieces from which the air is extracted after it enters the vacuum chamber.

There has been sufficient manufacturing experience to warrant the statement that marked improvements in certain physical characteristics of the finished paving brick are the result of the de-airing process. The rattler abrasion loss has been materially reduced in actual commercial production. Compression tests have run as high as 26,000 lb. per square inch, one series running from 18,000 lb. to 25,000 lb. per square inch which is comparable with granite. The absorption has been reduced and for certain individual tests has run less than 1 per cent. Laminations are greatly minimized and burning shrinkage reduced, which are important in securing a greater proportion of first grade product in manufacture. The weight is increased only about 4 per cent.

Against the advantages there have been some difficulties encountered in manufacture, principally in drying the green brick preliminary to burning. There has been insufficient experience to determine accurately the possibilities of savings in cost of production. However, it is believed that, due to a reduction of the loss now sustained in off-grade brick, there will at least be sufficient economy to give adequate return on the investment. It has been shown that the de-airing process will produce consistently and commercially a paving unit of greater strength and density, truer to shape and size and without increase in cost.

Resurfacing.—While the use of brick for resurfacing existing pavements can not be considered a new utilization there have been notable applications in recent years. Brick has been used for resurfacing both the rigid and flexible pavement types. Resurfacing and salvaging worn pavements will be of increasing importance in the highway improvement programs of the future. As most of the existing pavements in the heavy trafficed areas are concrete, this is the type with which most engineers will be concerned.

Resurfacing may be classified in three ways in all of which brick has been utilized:

(1) Covering the existing pavement with the addition of a course of brick including cushion and necessary shaping. The resurfacing of concrete pavements with brick has to date had its principal application to worn concrete highways and not city streets. The Illinois Division of Highways constructed over 60 miles of this type in 1931 and about an equal mileage in 1932. The experience of the Ohio Highway Department with resurfacing concrete with brick dates back to 1921 when State Route 332 in Geauga County was improved in this manner for a distance of 1.52 miles. According to a recent report the present condition is "good." The Indiana Highway Commission last year constructed its first brick-over-concrete resurfacing, the project being 3¼ miles in length on U. S. Route 41, south of Sullivan.

(2) Resurfacing an existing base course with brick. In the form that this type of reconstruction usually takes its is really a replacement operation. That is, the condition of the original surfacing material having become unsatisfactory, it has been removed and replaced with a new surface course after the old concrete base has been properly rehabilitated. Old brick (or a portion of them), after removal, have been relaid on the existing concrete base. There are also projects where a new brick top course has been laid on an old 2-course concrete base pavement without removal of the original surface. This may be considered as resurfacing a concrete base although there is an old intervening course.

(3) Relaying brick on existing base courses. There is no difference between this type of resurfacing and what has been referred to previously as replacement except that instead of new material for the new surface course the old brick are reused in whole or in part. Brick is unique in this respect among manufactured paving materials. Of course, new filler and usually new bed material are required.

As the removing and cleaning of the old brick before relaying is entirely a labor item, the cost will vary with the wages paid. The cost of cleaning is also dependent upon the type of filler used in the original construction. The extreme conditions would be represented by sand filler and a rich cement grout filler. Because of the factors mentioned the cost among different projects has varied from $1.00 to $12.00 per thousand of brick.

In most of the old brick pavements the brick were laid "on edge," that is, with the greater cross-sectional dimensions vertical. When relaid they are usually laid flat-wise, according to present day practices, and there is a gain in surface area. This fact affects the percentage of salvage measured by the area covered by the relaid brick. In some cases this has actually resulted in a salvage greater than 100 per cent and a surplus of brick which were used for additional paving. The general average is 75 to 80 per cent. Due to the increase in manufacturing costs since the brick pavements were originally constructed 20 to 30 years ago the relay value of the brick is in many cases materially greater than the original cost.

The Year's Progress in Concrete Pavement Practice

By W. E. BARKER
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THE year's practice in the design and construction of concrete pavement includes the simplification of formulas for pavement thickness and inclusion of the frequency of heavy loads as a factor in the design, the use of joints which prevent entrance of water to the subgrade and provide positive transfer of load across the joint, and the further development of rapid vibration as a means of consolidating pavement slabs.

Well-Banked Curves and Good Visibility on This 40 Foot Capital Highway in Multnomah County, Oregon

Development in Design.—The development in design was supplied by Frank T. Sheets, formerly state highway engineer in Illinois. Mr. Sheets has taken formulas derived by Dr. Westergaard, and published in various engineering periodicals and proceedings, and has reduced them to simple equations. Such simplification seemed essential to the use of the formulas since, in their original form, they were too formidable to be used by the average practicing engineer. The results secured with these rational equations agree so closely with the formulas on which they are based that, for all practical purposes, they may be considered identical.

The slab thicknesses and stresses calculated with the formulas were then checked against various experimental pavements in which the stresses were measured, or the breaking load was known, and were again found to agree almost exactly.

Traffic is provided for in the design of pavement thickness by estimating the expected traffic and from traffic counts on similar highways determining the number of loads of various weights that can be expected to use the road annually. The number of these loads that would be required to fatigue the concrete being known from experiments on fatigue, the expected life of the pavement for various designs can then be tabulated. A slab design can then be selected which will have the desired life at a reasonable cost.

It is expected that actual traffic counts or traffic estimates will be made in designing any particular pavement. Assuming a thickened edge section with shear bars along each edge and a mortised center joint held together by tie bars, slab thicknesses calculated for the different classes of highways are as follows:

Main highways in the metropolitan area—10 in.—6.7 in.—10 in.

Primary or state trunk highways bearing the average traffic of populous states—9 in.—6 in.—9 in.

Lightly-traveled primary or state trunk highways—8 in.—5.3 in.—8 in.

Secondary or county highways bearing average traffic in populous states—7½ in. —5 in.—7½ in.

These thicknesses are for concrete having a strength in flexure of 700 lbs. per square inch. For stronger or weaker concrete the thicknesses would be altered accordingly. Designs are also offered for slabs of uniform thickness and for those built without shear bars along the edge and without tie bars across the center joint.

It is expected that the new theory of slab design will result in large savings of highway money since in nearly every case considerably less concrete is required per mile than is now being used for comparable traffic. Its greatest application, however, is to roads carrying light traffic where the custom in the past has too frequently been to build a slab of the same traffic capacity as that used on the main-traveled roads.

Joints.—The past construction year was marked by an increase in the use of joints in concrete pavement. The tendency is toward joints at more frequent intervals. In the state of Illinois, for example, joints have been installed at 30-ft. intervals during 1933 where the pavements were laid in city streets, and for some country highways, instead of the old joint spacing of 800 to 1,000 ft.

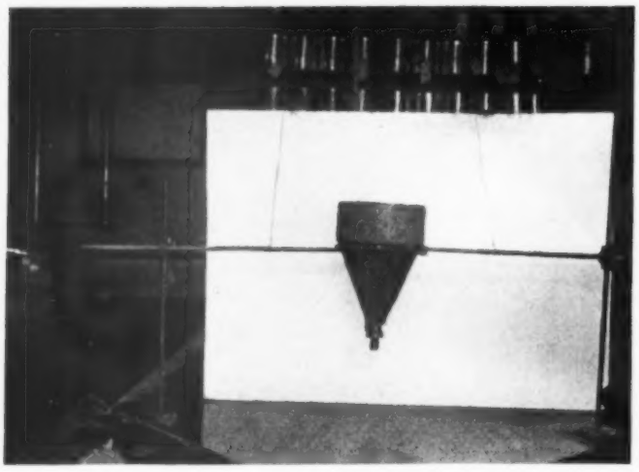
The greatest change in the use of joints has been the introduction of a new type of joint material. It is used in several different types of joints but consists essentially of a flexible metal cap or flashing extending across the top of the joint and sealing it against the entrance of water.

A problem receiving increasing attention is to design an economical, smooth riding, watertight, expansion joint, that will satisfactorily transmit a part of the wheel load to the adjacent slab.

Several types of joints developed to meet these requirements are being tried out.

A joint developed by the New Jersey Highway Department consists essentially of dowels in the shape of channels and a flexible metal seal for the top of the joint which bends as the joint opens and closes. To prevent crushing of the concrete beneath the channel dowels a transverse steel bar is installed on which they rest. In an experimental concrete pavement such a joint seemed well adapted to the heavy traffic conditions around New York City.

Another joint, used on several miles of Illinois highways this year, has a metal seal across the top of the joint, but load transferrence is accomplished by a horizontal dowel, running through the metal joint. These



Flow Cone for Testing Fluidity of Grout on Cement Bound Macadam

and other types of load transferring joints are receiving close attention.

The year also resulted in the more extensive use of a newcomer in the field of premolded joint material. This is a joint made of ground cork held together by a cementing material which is not affected by moisture or other forms of weathering. The joint has the desirable property of expanding to keep the joint space filled as the joint opens. It was used in 1933 on a limited mileage of pavement with apparent satisfaction.

Several other new joint materials were developed during 1933 but so far their use has been limited to a few experimental installations. The object of all these new fillers is to keep the joint permanently filled as contraction of the concrete widens the space between the ends of slabs.

Vibration.—In a year marked by greatly declining yardages of pavement of all types not many new methods of construction were in evidence. The application of rapid vibration to the consolidation of concrete pavement was the only outstanding construction development of the year.

Vibration had previously been tried experimentally in Texas, Missouri, and Illinois and on a test pavement built by the U. S. Bureau of Public Roads at Arlington. But in July, 1933, the New Jersey Highway Department definitely specified that all concrete pavements built under its jurisdiction should be consolidated by vibration.

Rapid vibration of concrete has found a definite place in the construction of buildings and in the making of many types of pre-cast units, where it has resulted in a definite saving, as well as in superior concrete. There is reason to believe that it will be equally successful in the concrete pavement field.

Use of Flow Cone on the Job of Cement Bound Macadam

So far there are three general types of vibratory equipment which have been used on pavements. The first is mechanical, in which the vibratory impulses are supplied directly by an internal combustion engine. The second is electrical and the third pneumatic.

In most of the installations tried up to the present time the vibrators have been mounted on a standard type of finishing machine. The finishing machine is usually supplied with an additional screed placed between the ordinary front and rear screeds. The vibratory impulses are applied through this screed. If the vibrators are of the electrical type two or three small electric motors are installed directly on the screed. They are supplied with current from a generator powered by a gasoline motor and mounted on the finishing machine.

The pneumatic vibrators have more frequently been placed upon a hand screed. They are supplied with air by a compressor outfit which moves forward as paving operations proceed.

All three types of equipment are still in the stage of development and it is impossible to say just what the final form of vibrator will be.

Placing Grout on Cement Bound Macadam Job, Elmhurst Test Road

Cement Bound Macadam.—Although construction was begun in the latter part of 1932 the revival of cement bound macadam really belongs to 1933.

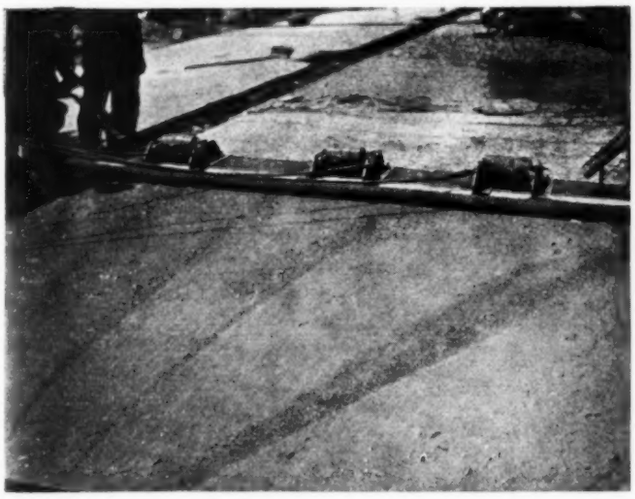
During the past season a total of 113,000 sq. yd. of cement bound pavement was constructed. In addition the Portland Cement Association built an experimental road which provided more information on this type of pavement than had been developed by all previous construction work. At the same time a piece of equipment was developed which makes successful penetration of any definite coarse aggregate a certainty.

Cement bound macadam pavement is built by depositing coarse aggregate on the subgrade and pouring over it a sand-cement grout of such consistency that it flows into and completely fills all the voids in the stone.

The test road indicated that gravel pebbles, crushed stone, and crushed blast furnace slag were all satisfactory coarse aggregates for cement bound macadam. It indicated also that the range between the maximum and minimum sizes of any coarse aggregate should not be more than 1½ in. For example, if the minimum size of

a stone were 1 in. the maximum size should not be more than 2½ in.

It was also found that from the standpoint of both penetration and strength the sand graded between that retained on a 100-mesh sieve and that passing an 8-mesh sieve was most satisfactory. Sand as coarse as that graded from the 100 to the number 4 sieves could be



Surface of Slab After Second Trip Over with Vibratory Screen, Cement Bound Macadam Test Road

satisfactorily used if the coarse aggregate particles were all large. For smaller coarse aggregate grout made of this coarse sand could not be made sufficiently fluid to penetrate all the voids without the danger of segregation of the constituents of the grout. A sand so fine that all the particles passed a 14-mesh sieve could be made into a far more fluid grout than either of the coarser sands but required a greater amount of water, which resulted in reduced strength.

Probably the outstanding discovery made on the test road was the fact that water losses into the subgrade, into the coase aggregates, and over the side forms reduced the water cement ratio to about that considered necessary for mixed concrete, and the core and beam strengths secured were about equal to those expected of

Broom Finish on Cement Bound Macadam Test Road

standard mixed concrete containing six sacks of cement per cubic yard.

Data were also secured which will make possible the accurate estimate of materials required when the different classes of construction equipment are to be used.

13,265 Miles Federal Aid Roads Completed

Employment during the fiscal year 1933 on Federal projects and highway projects, according to the report for the fiscal year ending June 30, 1933, of Thomas H. MacDonald, Chief of Bureau of Public Roads, amounted to 1,138,283 man-months, a gain—due mainly to the $120,000,000 emergency appropriation—of 577,673 man-months. Thus, employment was more than double the 1932 total. Winter employment on highway work was increased sharply. It was apparent that the greater total employment on all Federal and State highways in the summer of 1932, as compared with the summer of 1931, was due very largely to the Federal emergency highway appropriation.

Mr. MacDonald's report states that the mileage of Federal-aid roads constructed in the fiscal year 1933 was less than in the preceding year but greater than in any other year. Projects completed totaled 13,255 miles, of which a total of 8,503 miles was new construction, 4,700 miles stage construction, and 52 miles relocation.

Mileage of highways completed with Federal-aid funds to June 30, 1933, was 107,869 of the total of 206,277 miles in the designated Federal-aid highway system. Nearly all of the remaining mileage had been improved to some extent by the states.

Forest highways—the more important highways through the national forests—are built by the Bureau of Public Roads. Of this class of roads, Mr. MacDonald reports a completion of 359 miles during the last fiscal year and a total of 5,593 to date.

Road construction in the national parks, by agreement with the National Park Service, is supervised by the Bureau of Public Roads, and 174 miles were built in 1933, making a total of 674 miles thus far improved.

All field operations in connection with the reconnaissance survey of the proposed inter-American highway from Panama to the United States were completed before the end of the year and the report to Congress is in preparation.

Transportation, economic and statistical investigations were conducted in many states. A traffic survey in Michigan revealed that 50 per cent of all Michigan traffic is carried on the streets of cities, 17 per cent on township and county roads, and 33 per cent on the State highway system. Other traffic surveys were conducted in Indiana, New Jersey and in the regional area around Washington, D. C. Additional studies were made of traffic capacity and intersections, highway signs, uniformity in motor vehicle regulations, and taxation in Wisconsin, Michigan and Illinois.

Careful studies of road construction as an employment measure were made to determine the amount of labor entering into each of the various road building and maintenance operations, and the variation of the labor element with the use of machinery. It was found that about 90 per cent of the taxpayers' road dollar was eventually paid to workers as wages and salaries and, in addition, many widespread industries received a financial stimulus. Other studies were made of rolled concrete pavements, concrete from central mixing plants, low-cost road building methods, grading operations, and highway accounting methods.

Physical research investigations cover a wide range and include studies of motor vehicle impact, concrete pavement design, concrete and concrete aggregates with regard to vibration, delayed finishing and other tests, highway bridge investigations, measurement of the roughness of road surfaces, bituminous materials and low-cost roads, and subgrades.

Convention and Highway Exhibit *of A. R. B. A., Chicago*

THE annual convention and highway exhibit of the American Road Builders' Association will open in the Stevens Hotel, Chicago, on Monday, Jan. 22nd. This convention, coming at a time when the nation is beginning to pull out of the economic slump, with hundreds of millions of dollars being devoted to highway purposes as means to national recovery, will offer the various branches of the road construction industry their first opportunity since the inauguration of the new program to hold a coordinated discussion of their individual and joint problems. Since the industry is the backbone of the public works plan in offering maximum employment and maximum investment value for the money put forward by the government, and since the Public Works funds extend beyond the federal aid system of highways to the highways of the state and county systems and city streets, the A. R. B. A. convention sessions take on an even greater importance than heretofore.

From the opening convention session on Monday afternon, Jan. 22, through the technical sessions of the various divivisional organizations, problems relating to PWA and CWA projects will feature the discussions.

The delegates will consider in all their phases the questions of the retention of all gasoline and motor vehicle revenues for street and highway purposes, the restoration and continuance of federal assistance and guidance in highway construction and maintenance and the presentation to the taxpayers and legislators of information pointing to the necessity for a planned and economic program of highway development and maintenance to adequately care for transportation demands.

The outstanding address of the convention is expected to be delivered at the opening convention session on Monday afternoon by Thomas H. Macdonald, Chief of the United States Bureau of Public Roads. Mr. Macdonald will present a "Summary of Federal Highway Progress" telling of the federal government's activities and immediate plans for road building.

To Map Out Plan for Educational Campaign.—The convention will resolve itself into an open forum of the National Highway Advisory Council on the morning of Thursday, Jan. 25th. This session will bring together the leaders of every branch of the highway industry, representing every state and section of the country for an open and frank discussion of the problems which the industry is facing. At this time a plan of action designed to be carried through by the American Road Builders' Association in the interests of highway progress will be mapped out and the ground-work will be laid for a nation-wide educational campaign. This campaign will be designed to re-educate the public at large on the economic necessity for a sound construction and maintenance program to counteract reactionary movements which have been in evidence during the past few years. The program to be discussed calls for a comprehensive campaign utilizing all the media available for reaching taxpayers and taxing authorities to offset the harm that already has been done the highway program by the demands in many sections for a highway holiday.

The convention will start with the formal opening of the Highway Exhibit in the exhibition hall of the Stevens Hotel at 9 o'clock on Monday morning. This will be followed by a meeting of the board of directors and the first general open session at 2 o'clock that afternoon.

The Opening Sessions.—H. C. Whitehurst, Director of Highways of the District of Columbia and President of the American Road Builders, will sound the keynote in his opening address at this general session. Capt. Whitehurst then will introduce the presidents of the various divisions, R. Keith Company of the City Officials; Hal G. Sours of the County Officials; and W. T. Chevalier of the Manufacturers.

Charles M. Backcock, member of the Consumers' Advisory Council of the NRA and special representative of the American Association of State Highway Officials in Washington, will speak at this session on "Washington Observations of Interest to Road Builders." Mr. Babcock is unusually well-fitted to make such an address through his present work and his experience in the highway field as Commissioner of Highways for Minnesota for many years. He will discuss the problems of getting highways built, the status of the various NRA codes and their influence on the highway program, and such vital recovery questions as the construction of Civil and Public Works roads by hand labor instead of with the use of machinery as a measure of unemployment relief, pointing out the fallacy of eliminating machines from technical, social and economic standpoints.

O. S. Warden, chairman of the Montana State Highway Commission and President of the American Association of State Highway Officials, also will speak at this session. His subject, "The State and the Federal Government in Highway Development" will cover some of the most important questions to come before the convention. Mr. Warden is expected to point out the dangers confronting the highway program as a result of the uncertainty of the future of the federal aid and to propose a plan for continued federal participation with the states in highway development showing also that federal aid with its various maintenance and control features has been one of the greatest incentives to a planned national system of highways.

Divisional Sessions to Be Held on Tuesday.—Tuesday will be devoted largely to divisional sessions which will be followed by the divisional business meetings. The Manufacturers' Division will hold its discussions and election of officers in the morning and the afternoon will be taken up by concurrent meetings of the City Officials, County Officials and Contractors' Division.

It is proposed to hold a joint session of the city and county officials to discuss in detail the P.W.A. and C.W.A. programs and problems as they apply to various types of jurisdictions and then resolve the two divisions into separate meetings for studies of their specific interests. In addition to officials connected with the P.W.A. and C.W.A., Donald C. Stone, Director of Research, International City Mgrs. Assn., Chicago, Ill., will speak at this joint meeting, his subject being, "Simplified Methods of Cost Accounting for Public and Civil Works Projects."

The separate session of the City Officials Division will be devoted to a report on traffic entitled, "Can Traffic Fatalities Be Reduced?" by M. O. Eldridge, assistant director of traffic, Washington, D. C.

The County Officials' Division will hear an address by L. O. Marden, county engineer of Worcester, Mass., on "Monumentation of Highways" and one by Paul N. Coates, county engineer of Ramsey County, St. Paul,

Minn., on "The Selection and Supervision of Civil Works Projects by Counties." Mr. Marden will go into the many legal and technical problems involved in permanently establishing highway rights of way. Mr. Coates' address will be based on the results of a questionnaire recently sent out by him, through the American Road Builders' Association, covering the manner of selection, the types of projects and the administrative questions involved in the expenditure of C.W.A. funds.

All of these addresses on Tuesday will be followed by general discussions of the subjects.

Contractors to Be Organized as Separate Division.—The convention this year will see the formal organization of the highway contractors into a separate division of the American Road Builders. Heretofore, they have formed a branch but by authority of the General Board of Directors they will elect their own officers and board of directors this year for the first time. Louis Guyott, president of the Guyott Construction Co. of New Haven, Conn., and Chairman of the Highway Contractors Rules and Regulations Executive Committee, will be the principal speaker before the sessions of the Contractors' Division. He will explain the new rules and regulations for highway contractors as defined in the code for their industry and will lead in the discussion of other timely problems confronting them specifically.

The annual banquet, one of the highlights of the convention, will be held on the evening of Tuesday, Jan. 23. This event will bring before the members of the association an outstanding speaker and will consolidate the leading topics of the entire group of discussions, with the greatest bearing being placed on the federal government's recovery program, especially as it relates directly to the highway program.

General Technical Session on Jan. 24.—There will be a general technical session in the morning of Jan. 24 which will be featured by a paper prepared by Col. J. B. McCord, Maintenance Engineer of the Construction Division of the United States Bureau of Public Roads. Col. McCord will speak upon the subject of "Maintenance Cost Studies on Special Sections." Data is being derived from maintenance test road sections in every state including roads of various types, both on and off the federal aid highway system. At this session also H. F. Clemmer, Engineer of Materials, Washington, D. C., will speak and show slides dealing with the subject of "Early Strength Concrete—Effective Temperatures." Mr. Clemmer is well qualified to speak on this subject which fits in well with current technical needs.

Of utmost importance to every factor interested in the highway industry will be the general open session to be held on the afternoon of that day. Three of the most important addresses of the convention will be delivered at this time.

General Open Session.—E. B. Jeffress, Chairman of the North Carolina State Highway Commission, Raleigh, N. C., will speak on "Tomorrow's Highway Needs." He will outline in detail the problems of maintenance and replacement due to obsolescence and traffic changes that are bound to come within the next few years, even if any program of expansion of the present highway system is disregarded. He will explain the progressive road builder's view of the economic necessity of adequate feeder and secondary roads to prevent the present improved main highways becoming mere "tunnels" through the countryside. Mr. Jeffress also will give serious consideration to the problem of meeting the advance in modern automotive engineering by the construction of additional safeguards on highways, such as separated highway and railroad grade crossings, the elimination of dangerous curves, bottlenecks, both at bridges and intersections, and the construction of arterial and belt line thoroughfares in congested areas. He will take into consideration the part the P.W.A. and C.W.A. can play today in adjusting their programs to these future needs. He is expected to point out that a greatly enlarged, intelligent program for the future can be carried out economically entirely through the use of funds contributed by the users of these highways through gasoline taxes and revenues from motor vehicle licenses supplemented by a reasonable annual Federal Highway Appropriation. To divert gas tax and motor vehicle revenue funds, Mr. Jeffress is expected to point out, means one of two things, either forcing the general taxpayers to bear the burden of these economically necessary improvements by general taxation or to carry out a program that is entirely inadequate with all probability lying in the latter direction.

An address of nation-wide interest at the same session will be that of W. G. Armstrong of Niles, Mich., president of the National Rural Letter Carriers' Association. Mr. Armstrong will discuss the rural postman's view of good roads in the light of the 1,250,000 miles covered daily by members of his association. His address, "Roads Over Which the Mail Is Carried," will point out that more than a million miles of post roads are still unimproved and serve approximately one-third of all the farms in the United States. He will present the view of the letter carrier and rural resident in pointing out the need for a more carefully planned and carried out program of feeder and secondary highways.

The third outstanding speech at this open session will be that of Roy W. Crum, director of the Highway Research Board. Mr. Crum will talk on "The Highway Balance Sheet" and will present a discussion of a formula developed by him for the determination of the desirability of a specific highway project. Mr. Crum, by a careful study of all the factors which make a road necessary, will propose a specific set of rules, which if followed will give a definite answer to highway officials, appropriating authorities and taxpayers when the question is asked, "Is This Highway Needed?" He has carefully sifted, and credited with their share of importance, the elements of social advantages, economic necessity, traffic and technical needs in laying the foundation of his theory.

A dinner meeting will be held by the Pan-American Division of the Association Wednesday evening, followed by the annual International Ball, the most colorful social event of the convention.

At the Pan-American Dinner, Leopoldo Farias, president of the division and director of highways in Mexico, will describe the progress being made on the great Inter American highway which is planned to link all the countries of the Western Hemisphere eventually. Next Fall the link from the United States to Mexico will be formally opened and a motorcade from this country will make the trip to the capital of the southern republic as the first official passage over the highway. Mr. Farias at the Chicago convention will discuss plans for this tour.

The Highway Exhibit.—This year's highway exhibit, for the first time in many years is housed under the same roof as the convention itself. The exhibits are marked by many improvements and developments that have been brought out by manufacturers during the past seasons of industrial inactivity. Rapid strides have been made in many lines relating to the highway industry and many newly designed materials and processes have been brought out in addition to the refinements in the uses of materials. The exhibition in addition to the commercial exhibits, has a number of excellent technical and educa-

tional exhibits by the United States Bureau of Public Roads and the Department of Commerce, Bureau of Foreign and Domestic Commerce.

The Annual Election of Officials.—The official ballot, as selected by the nominating committee of the Association, follows:

For president, H. C. Whitehurst, director of highways, Washington, D. C.; vice president, northeastern district, E. L. Benedict, vice president, Pittsburgh Steel Company, Pittsburgh, Pa.; vice president, Southern district, Charles M. Upham, engineer-director, American Road Builders' Association, Washington, D. C.; vice president, Central District, Grover C. Dillman, Director of Public Service, Grand Rapids, Mich.; vice president, Western District, Stanley Abel, supervisor, Kern County, Taft, Calif.; treasurer, James H. MacDonald, Consulting Road and Paving Expert, New Haven, Conn.; Directors, Robert B. Brooks, consulting engineer, St. Louis, Mo.; Paul L. Griffiths, vice president, Koppers Products Co., Pittsburgh, Pa.; A. Lee Grover, Secretary, New Jersey State Highway Department, Trenton, N. J.; L. B. McLeod, president, L. B. McLeod Construction Co., Williston, Fla.; J. E. Pennybacker, Managing Director, The Asphalt Institute, New York; George C. Stanley, city engineer, Burlington, Vt.; and J. Borton Weeks, president, Keystone Automobile Club, Philadelphia, Pa.

The official ballot for the County Highway Officials' Division is as follows:

For president, E. L. Gates, County Superintendent of Highway, Wheaton, Ill.; vice president, northeastern district, J. A. Bromley, County Roads Engineer, Annapolis, Md.; vice president, southern district, C. C. Thacker, Secretary, Davidson County Highway Commission, Nashville, Tenn.; vice president, central district, J. W. Mavity, county engineer, Newton, Kans.; vice president, western district, Stanley Abel, supervisor, Taft, Calif.; Directors, R. D. Alverson, County Engineer, Everett, Washington; H. G. Culverhouse, Superintendent of Roads, Birmingham, Ala.; L. P. M. Gaylord, County Supt. of Highways, Lowville, N. Y.; Otto S. Hess, Engineer-Manager, Kent County Road Commission, Grand Rapids, Mich.; H. B. Keasbey, County Engineer, Salem, N. J.; J. C. McLean, County Engineer, Sioux City, Iowa; L. O. Marden, County Engineer, Worcester, Mass.

The official ballot for the City Officials' Division is as follows:

For President, Bryson Vallas, General Superintendent, New Orleans, La.; vice president, northeastern district, Dudley T. Corning, Chief, Bureau of Highways, Philadelphia, Pa.; vice president, southern district, H. D. Palmore, City Manager, Covington, Ky.; vice president, Central District, J. M. Tippee, City Engineer, Des Moines, Iowa; vice president, western district, J. C. Albers, City Engineer, Glendale, Calif.; Directors, Wm. N. Carey, Minnesota State Engineer, Public Works Administration, St. Paul, Minn.; Walter N. Frickstad, City Engineer, Oakland, Calif.; P. W. Maetzel, Chief Engineer, Dept. of Public Service, Columbus, Ohio; Frank J. McDevitt, Director, Streets and Sewers, St. Louis, Mo.; A. E. Roche, Commissioner of Public Works, Troy, N. Y.; J. E. Root, Director, Department of Public Works, Cincinnati, Ohio, and Geo. C. Stanley, City Engineer, Burlington, Vt.

The Exhibitors.—Member firms and organizations which will have exhibits on display and those which have otherwise made financial contribution to the work of the A.R.B.A. include the following:

Abram Aerial Survey
Ahlberg Bearing Co.
American City Magazine
American Concrete Expansion Joint Co.
American Manganese Steel Co.
American Sealdrok Corp.
Armco Culvert Manufacturers Assn.
Athey Truss Wheel Co.
Austin-Western Road Machinery Co.
Barber Asphalt Co.
Barrett Co.
Black and Decker Mfg. Co.
Blaw-Knox Co.
Philip Carey Co.
J. I. Case Co.
Calcium Chloride Assn.
Chain Belt Co.
Chevrolet Motor Co.
Cleveland Pneumatic Tool Co.
Cleveland Tractor Co.
Concrete Surfacing Machinery Co.
Continental Roll and Steel Foundry Co.
Contractors and Engineers Monthly
Ditwiler Mfg. Co.
Dow Chemical Co.
Equipment Corp. of America
Everhot Mfg. Co.
Four Wheel Drive Sales Co.
Fuller Company
Fuller Manufacturing Co.
General Motors Truck Co.
W. S. Godwin Co.
Hauch Manufacturing Co.
Heltzel Steel Form & Iron Co.
Hetherington & Berner, Inc.
Chas. Hvass and Co.
Hyatt Roller Bearing Co.
International Harvester Co.
Johns-Manville Corp.
Kinney Mfg. Co.
Kob Mfg. Co.
Koppers Products Co.
Lakewood Engineering Co.
A. Leschen & Sons Rope Co.
Libbey Cataphote Corp.
Littleford Bros.
Macasphalt Corp. of America
McGraw-Hill Publishing Co.
Medusa Portland Cement Co.
National Bituminous Pavers Industrial Assn.
National Paving Brick Assn.
Tinius Olsen Testing Machine Co.
Ohio Oil Co.
Page Steel and Wire Co.
Pit and Quarry
Portland Cement Assn.
Public Works
R. B. Equipment Mfg. Co.
Roads and Streets
Scintilla Magneto Co.
Signal Service Corp.
Sinclair Refining Co.
Skinner Motors, Inc.
Solvay Sales Corp.
Stedfast Rubber Co.
Studebaker Sales Corp.
Templeton, Kenly & Co.
Timken Roller Bearing Co.
Toncan Culvert Mfrs. Assn.
Trackson Co.
Tuthill Spring Co.
Universal Atlas Cement Co.
Universal Crusher Co.
The Vellumoid Co.
Walter Motor Truck Co.
Williamsport Wire Rope Co.
Wisconsin Motor Mfg. Co.
Wood Hydraulic Hoist and Body Co.
Youngstown Pressed Steel Co.
Edward Zaremba Snow Pumps

Members otherwise making financial contributions:
Buffalo Springfield Roller Co.
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E. D. Etnyre & Co.
Metropolitan Paving Brick Co.
Novo Engine Co.
Schramm, Inc.
Shell Petroleum Corp.

Developments in the Use of Tar for Highways

By Geo. E. Martin
Consulting Engineer, General Tarvia Department, The Barrett Co., New York City

THE year 1933 has been marked by a gradual development and improvement in the use of tar rather than any sudden and drastic changes. The tried and tested materials and methods over a long period of years have not been abandoned and replaced by entirely new things. Rather the old stand-bys have been retained in their main features and only changed and modified to utilize new knowledge as it has been obtained. For that reason, the developments recorded here will not be dramatic and unprecedented but they are important, nevertheless.

Building Tarvia-Lithic Surface in Winter in New Jersey

Surface Treatments.—Formerly, prime coat tars, with an Engler Specific Viscosity at 40° C. of 8 to 13 or 13 to 18, were always used and their well-known penetrating and binding properties depended upon for consolidating the sand-clay, sand, gravel or macadam surface. This is still a very successful practice in many sections of the country. However, some road officials have wished to obtain the penetration into the top crust by mixing the tar and aggregate by means of a blade grader, maintainer, drag or similar machine. While good work is done with the prime coat tars, somewhat heavier materials, having an Engler Viscosity at 40° C. of 18 to 25 or 25 to 35, are being used. These materials set up somewhat more quickly under traffic and the mixing operation insures as complete penetration as when the lighter materials are used.

In the realm of the so-called cold surface treatment materials, defined as those which can be removed from the tank car without heat although they must be warmed for use on the road, a new grade of material with an Engler Specific Viscosity at 50° C. of 26 to 36 has been utilized. This grade was developed as a "re-tread" binder but has proved to be a successful surface treating material. Its chief use has been in the re-treatment of bituminous surfaces and the surface treatment of concrete and brick. It produces a somewhat heavier and tougher surface treatment than the lighter cold surface treatment materials and while it sets quicker it can still be dragged like them.

Many new gravel roads have been treated with tar during their construction. Cold surface treatment or light re-tread binders have been used for this purpose. Mixing machines of various sorts have been used to mix the tar and gravel. Usually the top 3 or 4 ins. of the gravel has been mixed with the tar using about ⅔ gal. of tar per square yard. A seal coat of approximately ⅓ gal. of the same grade of tar was used.

Dragging of surface treatments has steadily increased. This operation distributes the tar over the surface of the covering aggregate. It also results in much easier riding surfaces. All of the cold surface treatment tars and the "re-tread" binders can be dragged. Hot surface treatment tars should not be dragged under ordinary circumstances, but the cover may be broomed or broom dragged and rolled.

Another use for the surface treatment tars has been in their application to slippery roads to produce non-skid surfaces. The tars adhere to the smooth, slick surfaces and hold the aggregate placed on them with their granular texture exposed to grip the tires and hold the vehicles in place. This is a permanent and not a temporary condition since the tars will not bleed up over the top of the aggregate.

Re-Tread.—The "re-tread" or mixed-in-place type has continued to increase in popularity due to its inherent qualities and to the growing demand for low cost highways.

As highway officials have become more familiar with the type and better organized to carry out the work, there has been a demand for methods and materials which would permit the work to be finished more quickly. To meet this demand, heavier tars have been developed, present general practice being to use those with an Engler Specific Viscosity at 50° C. of 16 to 22 for winter, spring and fall work and 26 to 36 for summer work. In some instances a hot surface treatment tar with a float test at 32° C. of 60 to 150 seconds has been used.

When the heavier tars are used all of the binder is sprayed at one time and the seal coat spread in two applications.

In this type of construction all of the stone for the total

Spreading Tar on Gravel on a New York State Road

Mixing Tar and Gravel on a New York State Road

depth is spread on one side of the road. Tar is then sprayed on the stone at the rate of approximately 1½ gals. per square yard for the 5-in. depth of stone over half the width of the road. The tar and stone is then turned over a few times, spread out over the road surface and rolled. The surface voids are then filled with small-sized stone chips, New York uses No. 1A stone ranging in size from ⅛ in. to ¼ in. on square mesh screens. This material is swept into the voids during the rolling. A first seal coat of the same grade of tar used for the mixing is applied at the rate of approximately ¼ gal. per square yard. This treatment is covered, swept and rolled and a second seal coat of the same amount applied. Covering, sweeping and rolling completes the job. The amount of tar required would be as follows:

	gal. per sq. yd.
Mixing	.75
First seal	.25
Second seal	.25
Total	1.25

This modified type of re-tread permits the rapid construction of the road where the work is well organized and plenty of equipment available.

Plant Mixes.—Plant mixes, using tar binders, have been of the hot mix, cold laid variety. Usually the materials are produced to meet definite specifications and such changes as have been made were made to meet the desire of the customer. In this connection, there has been a tendency to require somewhat smaller aggregate and a tighter, more thoroughly filled surface. This has been true in all sections of the country, except New England, where the engineers desire an open, rough textured surface.

Tar Gravel Mulch on a Road in New England

Practically all of the mixed material is now hauled from the plant to the job in trucks. Car shipments are the exception rather than the rule.

Plant mixes were used extensively during the year for the re-surfacing of concrete, brick and similar pavements.

There is a growing tendency on the part of political organizations to use plant-mixed tar concrete for maintenance work rather than mix their own.

Winter Work.—Not so long ago all road work, except in the extreme southern states, stopped during the winter months. However, during the past year there has been a demand for continued public works in the winter when the unemployment situation is most critical. This condition has not changed for this winter. As a result of this demand, tar was used during all of the months of the winter of 1932-1933. As a general proposition, the liquid tars can be successfully applied when the road is damp, but not wet. Covering and rolling operations must follow closely behind the application of the tar. The plant-mixed tar concrete can be very readily handled during the winter.

One example of work of this sort, using a tar-bound macadam foundation and a "Tarvia-lithic" (plant-mixed tar concrete) top, is the paving of Glenside Ave., near Summit, N. J., for the Highway Department of Union County. This work was fully described in the November issue of ROADS AND STREETS.

Dragging Tar Gravel Mix on a New York State Road

Standard Grades.—An effort has been made during the year to select standard names and consistencies for the various grades of tar used for highway work. The following grades have been tentatively selected for coal tar road materials and are now being considered by the various interested parties.

SUGGESTED GRADES—COAL TAR FOR HIGHWAY USE

Use	Name	Consistency
Prime coat	TC-1	Spec. Visc., Engler, 50cc at 40°C. 8-13
Prime coat	TC-2	Spec. Visc., Engler, 50cc at 40°C. 13-18
Cold surface treatment	TC-3	Spec. Visc., Engler, 50cc at 40°C. 18-25
Cold surface treatment	TC-4	Spec. Visc., Engler, 50cc at 40°C. 25-35
Re-tread binder	TM-1	Spec. Visc., Engler, 50cc at 50°C. 16-22
Re-tread binder	TM-2	Spec. Visc., Engler, 50cc at 50°C. 26-36
Hot surface treatment	HT-1	Float Test at 32°C. 60-150 seconds
Hot surface treatment	HT-2	Float Test at 32°C. 150-210 seconds
Crack filler and binder	TP-1	Float Test at 50°C. 100-160-seconds
Penetration macadam	TP-2	Float Test at 50°C. 160-220 seconds
Cold patch	TCP-1	Spec. Visc., Engler, 50cc at 40°C. 35-60
Cold patch	TCP-2	Spec. Visc., Engler, 50cc at 40°C. 60-80

Conclusion.—The year has been marked by a gradual change in the use of tars in highway work rather than any sudden and complete overthrow of the old methods with the substitution of new ones. New ideas have been adopted but their introduction has been gradual so that their advantage has been obtained without the risk of new and untried experiments.

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Roads from Farms to Rails and Markets

By CHARLES DAVIS,* C. E.

Founder, Trustee and President National Highways Association

IN the old days our steam railways insisted that road building was purely a local question. By that they meant township, town, or county. The great exponents of this idea are now against most road improvements, whether through or local. Some few say so frankly. Many more are but say the contrary. But "actions speak louder than words." Or as Alfred Adler says, "Watch the action line" if you want to know the truth. The opposition to road building by the steam railways is largely based on the claim that they must build and maintain their rights of way and are taxed thereon while motor vehicles for hire travel over a right of way that is donated to them and maintained for them free of cost. Of course this claim cannot be substantiated. First, because motor owners help pay the taxes that build and maintain these roads. Second, they pay a special license tax. And third, a tax on gasoline, their fuel. And anyhow such an argument does not apply to minor roads that feed the railways and radiate out from centers of population. For these roads carry goods and people where rails do not exist and carry them to those rails.

It is hard to think of anything better calculated to be profitable to our steam railways than to improve 600,000 miles of minor roads. The hauling of the material to build them would mostly be done by the railways. The increase of rail traffic as a result of such widespread improvements of minor roads throughout our country can hardly be estimated.

These 600,000 miles of lightly built, smooth surfaced roads would give us "good roads everywhere" for they would serve close to 80 per cent of our rural or farm population not now on main or trunk highways. The following table briefly outlines the plan:

A PLAN TO BUILD ROADS FROM FARMS TO RAILS AND MARKETS

Miles of minor road to improve	600,000
Average cost per mile	$10,000
Total cost	$6,000,000,000
Cost to federal government	$3,000,000,000
Cost to states	$1,500,000,000
Cost to counties	$1,500,000,000
Average cost per state	$30,000,000
Average cost per county	$500,000
Average population per county	40,000
Total cost per person in county	$12.50
Interest per county per annum at 5 per cent	$25,000
Interest per person per annum at 5 per cent	62½ cts.

If Uncle Sam provides all the money through Federal sources it can be secured most cheaply. If the states reimburse Uncle Sam for half that cost the difference in interest charged the states by Uncle Sam and the cost of the money to Uncle Sam will retire any obligations issued by Uncle Sam within a period of 50 years.

What better to do for the 120,000,000 people of the United States of America? What beter to do for re-employment for 80 per cent of the money spent would go into labor and help solves the problems of our NRA.

The National County Roads Planning Commission was established to study the proper planning of these minor roads. It was originally set up by the American Road Builders' Association, the Lee Highway Association and the National Highway Association. Later the Universal Portland Cement Association, National Crushed Stone Association, American Tar Products Association, Portland Cement Association, The Asphalt Institute, National Paving Brick Manufacturers' Association, National Rural Letter Carriers' Association, together with various individuals, joined. It is a voluntary, non-profit organization led by public-spirited men giving their time and skill, of which Major George W. Farny, Vice-president National Highways Association, is chairman.

*Life Member and Member Legislative Committee, American Road Builders' Association; Life Member American Automobile Association; Member National County Roads' Planning Commission.

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Time Savings Will Pay Interest on Road Cost

Savings of vehicle time due to the construction of the high level viaduct, a 3.7-mile highway built at a cost of $19,300,000 between Newark and Jersey City, N. J., to serve the Holland Tunnel entering New York City, amount to as much as 66 million vehicle-minutes per year. This estimate of time saving was one of the results of traffic studies made by the Bureau of Public Roads, U. S. Department of Agriculture, as reported by L. S. Tuttle, Assistant Highway Economist, to the annual meeting of the Highway Research Board of the National Research Council which opened Dec. 7 in Washington, D. C.

Field studies by cooperating traffic engineers of the Bureau of Public Roads and the New Jersey Highway Commission show the average daily traffic on the viaduct to vary from 30,000 to 45,000 vehicles a day. Valuing a vehicle-minute at 2 ct., the 6 per cent interest charge on the cost of the structure is equaled by the savings of highway vehicle time. Among the additional benefits are the travel distance saved by shortening the road and relief from traffic congestion.

The route used before the viaduct was built was 4.2 miles long with two draw-bridges that frequently delayed traffic. The viaduct route is 3.7 miles long, provides for two lines of traffic in each direction, has no highway intersections at grade, and traffic is not delayed by lifted draw-bridges. Traffic was studied on the old route before the new one was opened and then on the new route, and the time savings of the new route were determined.

To estimate the vehicle time saved by the viaduct, the average trip time was measured between the same points on each route. A method of observing the last four digits of vehicle license numbers was used, the vehicle numbers at both ends of the route being noted. A card for each minute of observation time, on which were listed the license numbers of all passing vehicles, facilitated the work.

The vehicle-minutes saved each year because of the improvement of the viaduct route, according to the findings of the traffic survey, are estimated at the following minimums: Passenger cars, 57,445,000; light trucks, 4,883,000; heavy trucks, 3,827,000.

Sodium Vapor Street Lights Set Precedent in America

A NEW street lighting installation, recently dedicated along Park Avenue in Port Jervis, N. Y., sets a precedent in this country. It is the first ornamental type of installation of sodium vapor lamps for operation on alternating current.

Planned as a part of the unemployment relief program, the new street is city-owned, including the ornamental standards and feeder circuits. It extends approximately ½ mile, is 30 ft. wide, and cuts through the side of Mount William on the outskirts of Port Jervis to provide a new gateway to the city as well as a new entrance to the Delaware Valley from the East.

Twenty-five Westinghouse sodium vapor lamps are mounted some 14 ft. above the ground on hollow steel standards to illuminate the roadway. The standards are spaced 125 ft. apart along the outer edge of the roadway, about 6 ft. from the curb line. Nominally rated at 4,000 lumens, the lamps are enclosed in heat-insulating vacuum cylinders resembling "thermos bottles," and in turn are surrounded by Bi-lux Bowl refractors. Special Gillinder outer enclosing globes, some 18 in. in diameter and consisting of light density, opalescent glass, complete the post-top equipment.

Individual Transformers.—Within the base of each post is mounted a special Westinghouse transformer

The Sodium Vapor Lamps Along Park Avenue in Port Jervis, N. Y., Constitute the First Street Lighting Installation of This Nature in America.

which operates on a 6.6 ampere series primary circuit. These deliver, through the four-wire secondaries up the posts, the two voltages required for the operation of each sodium lamp.

The series circuit, supplying the Port Jervis installation, is part of a straight a.c. system now feeding other series Mazda filament lamps from a standard automatic tub transformer. A clock switch throws in the lamps at dusk and they burn until dawn, approximately 14 hours at this season. Power to the installation is supplied by the Rockland Light and Power Company.

When in full operation the power consumed per lamp is slightly under 100 watts. The overall efficiency of each lamp, including transformer and secondary wiring, is in the neighborhood of 40 lumens per watt. This output efficiency is almost twice that of the corresponding metallic filament lamp, a factor which constitutes one especial virtue of certain metallic vapor illuminants.

When inaugurating trial installations with sodium lamps, both here and abroad, it was considered preferable to plan them primarily for interurban highways or for routes handling vehicular traffic and where pedestrians seldom appear. This choice was partially based upon the question as to whether the monochromatic yellow color, incapable of correction by the screening method of accessory glassware, might prove unfavorable to human complexions. Where the sodium lighting intensities are low, as compared to sidewalk illumination from show windows and signs, it is quite likely that this red-deficient color may be so diluted as to be unobjectionable.

Lamps Recently Made Practical.—Sodium vapor lamps have been under development since 1916 when Westinghouse received certain patents on its design.

At Night the Sodium Vapor Lamps Spread An Even Illumination Over the 30-ft. Roadway.

Ever since then, engineers have been handicapped by the lack of a glass which would withstand the deteriorating effects of the chemical reaction brought about by the glowing sodium vapor. Discovery of such a glass this year climaxed the sodium vapor lamp into a design that would serve as a practical light source.

Many States Make Highway Awards

Progress in award of contracts for public works highway construction has been so rapid in many states as to leave only small balances of the appropriated funds still available for allotment, according to reports of the U. S. Bureau of Public Roads.

At the end of the year, 64 per cent of the $400,000,000 provided for emergency construction of highways by the National Industrial Recovery Act had been taken up in work advertised for contract or started by day labor employed directly by the highway authorities. Kansas had awarded to contract all the work possible with available funds. There are 26 other States that have exceeded the average rate of progress in putting the road money to work as indicated by reports of work advertised for contract or started by day labor. These States and the percentages of available funds they have taken up are:

Arizona, 70.7%; California, 68.6%; Connecticut, 94.8%; Delaware, 69%; Florida, 76.7%; Idaho, 65.6%; Iowa, 71%; Kansas, 100%; Maine, 79.9%; Michigan, 69.9%; Missouri, 70.9%; Montana, 70.5%; Nebraska, 82.8%; New Hampshire, 76.2%; New Mexico, 76.1%; New York, 93.8%; Ohio, 74.2%; Oregon, 78.1%; Pennsylvania, 77%; Rhode Island, 73.2%; South Carolina, 66.7%; Utah, 83.8%; Vermont, 81.9%; Washington, 81.4%; Wyoming, 68.9%; District of Columbia, 97.3%; Hawaii, 80.8%.

A total of 5,287 projects, estimated to cost $273,849,000, had been advertised for contract or begun with day labor up to December 30, the bureau states. The cost of the day-labor projects included in the above is estimated at $20,160,000.

Research Activities of the Bureau of Public Roads in 1933

NEW developments in highways and in the vehicles made possible by the highways have followed rapidly one upon another during the past decade. The 3,000,000 miles of public highways and the many additional miles of busy city streets over which pass back and forth some 24,000,000 vehicles have developed problems and a field for economic, social and physical research with a rapidity that is astonishing.

The Bureau of Public Roads has sought to meet the demand for new and accurate information created by this situation through the development of sustained research activities designed to supply accurate information about troublesome problems.

This research work is organized by the bureau to discover useful facts in several fields of investigation:

Materials are investigated as to the properties useful in building roads and their behavior in highway structures. The purpose is to insure the use of satisfactory materials in Federal-aid roads, and to develop new information that will be helpful in promoting more effective and economical highway construction. Highway structures and the road as a structure are also investigated.

Methods of construction are studied with a view to reducing highway costs through better organization and working conditions. The use of road construction as an employment measure and other similar labor matters are considered scientifically and sympathetically. Trends of costs as influenced by materials, specifications and construction practices are determined. The development of accurate and effective highway accounting methods is investigated.

Transportation studies are made to determine the amount of existing traffic on highways and city streets, its probable development, and its variations. Safety devices and traffic control apparatus are investigated together with laws for traffic regulation.

Economic use of highways as they affect the welfare of the public and other means of transportation are investigated. The effect of highway and vehicle taxation, the income derived from the taxation of roads and motor vehicles, and statistics as to matters such as vehicle fuel consumption, road mileage and type of improvement are studied in detail.

In addition to these broad fields of investigation, there are many special research problems that arise and are given attention. A summary of the research work in progress during the fiscal year ending June 30, 1933, shows intense activity and definite progress.

Physical Research

Motor-Vehicle Impact Investigations.—A report has been published covering in detail the study of the impact reactions produced by a heavy motor bus.

A limited study was made of the impact reactions of a heavy passenger car and of those of a light truck equipped with high-pressure pneumatic tires. Tests with these vehicles were made over actual pavement surfaces. The relation between the magnitude of the reactions developed and the frequency of occurrence was established for each vehicle and the trends of the data were compared with similar data obtained in the bus tests. A complete report of this study has been prepared.

A program of tests has been outlined for the study of the effect on road surfaces of the suddenly applied forces of motor-vehicle impact. This program includes a series of tests to determine the relative effects of static and impact forces on massive concrete specimens under carefully controlled conditions. For this work a specially designed pendulum-type impact machine has been designed and is being built. Comparative static and impact tests on actual pavement slabs will follow the series of laboratory tests.

Investigation of Concrete Pavement Design.—An investigation, which has for its object the development of information to assist in a better understanding of the structural action of concrete pavement slabs and thus lead to improved structural design neared its conclusion during the past year. Many loading tests and other observations have been made, and a considerable amount of new information of a definite and conclusive nature has been developed.

A series of reports has been outlined and preparation of the reports has been started.

Investigations of Concrete and Concrete Aggregates.—Previous investigations of pavement concrete involving the construction and testing of full-size pavement slabs have yielded valuable information regarding the effect of variations in materials and construction practices on the strength and uniformity of the concrete. The major conclusions from the first series of tests were given in the 1931 annual report of the Bureau of Public Roads. In the second series, the effect of using high-speed vibrators mounted on the screeds of the finishing machine and the effect of delayed finishing for the purpose of removing excess water were studied. The portion of this investigation dealing with strength and uniformity has been completed and a report issued. The major conclusions were as follows:

Effect of Vibration.—By the use of vibrating equipment of the general type used in these tests it should be possible to place satisfactorily and to finish concrete considerably drier than is possible with methods now in common use.

For conditions comparable with these tests, it should be possible satisfactorily to place and finish by vibration concrete having a minimum slump of 1 in. as compared to a minimum slump of 2½ in. by methods now in common use.

These tests indicate that, depending on the type of coarse aggregate used, concrete containing from one-fourth to three-fourths parts more coarse aggregate than the base mix, if vibrated, should show as great uniformity and as high flexural strength as the base mix finished by methods now in common use. Such a mix will contain approximately from 0.2 to 0.6 sack of cement per cubic yard less than the base mix.

The indications of these tests are that the effect of vibration is more marked where angular coarse aggregates are used than where aggregates having rounded surfaces are used.

Effects of Delayed Finishing.—The use of the method of delayed finishing as carried out in these tests will increase the density and strength of concrete pavement slabs, by eliminating, before final consolidation, a larger quantity of excess water than is accomplished by methods now in common use.

The application of the method of delayed finishing to a mix containing approximately one-half part more fine

and 1 part more coarse aggregate than the base mix will produce pavement slabs having substantially the same crushing and flexural strength as the base mix finished by methods now in common use. Such a mix will contain approximately one sack of cement per cubic yard of concrete less than the base mix.

In general, the indication of these tests are that the proper use of either the vibratory method of finishing or the method of delayed finishing should result in an improvement of the quality of concrete pavements. Tests are now under way to determine the effect of these special methods of finishing on the ultimate durability of the concrete as measured by freezing tests on cores cut from the test section.

Other Concrete Tests.—Several studies of improving concrete as to its durability or resistance to weathering are being continued. In one series, a number of mortar specimens containing various types of concrete sand are being subjected to alternate freezing and thawing to develop information which will make it possible to include in specifications definite quantitative requirements designed to insure durability of fine aggregates.

In an effort to improve existing methods of testing the wear-resisting qualities of coarse aggregates, a study was undertaken of the so-called "Los Angeles rattler" test used by the State of California. It has been claimed that this test is superior to the existing standard method because it is possible to test both crushed stone and gravel by the same method, thus eliminating the necessity for two separate specification requirements as at present. These tests were conducted in cooperation with the American Association of State Highway Officials, and a report is now being prepared for publication.

An investigation has been started to develop a standard laboratory procedure for testing the numerous new methods and materials for curing concrete. Of these methods, one which presents interesting possibilities, not only as a means of curing but also as a means of insulation, involves the use of a cotton mat formed of one or more layers of raw cotton placed between sheets of cotton cloth. A laboratory study of this material showed quite definitely that the cotton mats were not only effective in providing insulation against the sun's rays but were also as efficient, from the standpoint of curing, as a double thickness of burlap kept wet 3 days. The results of this investigation have been published.

Attention has been called recently to the extreme importance of controlling the temperature and moisture content of concrete specimens at the time of test if reliable results are to be obtained. One series of tests has been completed and a report prepared. Another series involves tests, at various periods up to 1 year, of concrete containing both normal and lightweight aggregates stored and tested under both wet and dry conditions. These tests should also yield information of value as to the effect of artificial lightweight aggregates on the strength of concrete at different ages and under various curing conditions.

Highway Bridge Investigations.—A complete report of the cooperative investigation of the Freyssinet method of arch construction as applied to the Rogue River bridge in Oregon has been completed and is being published as a bulletin of the Oregon Highway Commission.

A cooperative study of multiple-span reinforced-concrete arch bridges has been completed at the University of Illinois. This study was made for the purpose of determining the effect of spandrel structures of various types and elastic piers of various heights on the action of concrete arches. For this purpose several multiple-span arch ribs, each of three 26-ft. spans, were built in the laboratory and deformation measurements made under loads of different intensities and distribution. The factors studied were spacing of expansion joints in the deck, height of deck above the rib at the crown, and height of elastic piers. Much information that will be useful to bridge designers was developed by this study. A complete report is now being compiled.

Tests to determine the friction developed in the sliding of expansion bearings of highway bridges, when the bearing plates are made of various materials and finished in different ways, were mentioned in last year's report. During the past year the schedule of tests has progressed steadily. Several hundred tests have been made, and an appreciable range in the coefficient of friction has been found to exist. The information obtained in this investigation should assist bridge engineers materially in designing sliding bearings.

Measurement of Road Surface Roughness.—Several years ago the Bureau of Public Roads developed a device, to be mounted on a motor vehicle, by which the successive deflections of the front springs of the vehicle, caused by the surface roughness of any road over which it might be driven, could be summed up and recorded in inches. The device was intended to indicate the relative roughness of road surfaces by the relative amounts of spring deflection recorded on different roads. With full realization of its limitations it has been used in many parts of the country. Its principal shortcoming is that the general level of the values recorded is affected by the vehicle characteristics (springs, weight, tire equipment, etc.), so that it is not possible satisfactorily to compare data obtained with the instrument mounted on different vehicles.

This deficiency led to an investigation of the possibility of developing a standardized vehicle which could be used with the relative roughness indicator. A single-wheel trailer has been built, capable of standardization in all of its parts and the work done with it thus far gives promise that it may be satisfactory. It is relatively simple to build and can be readily attached to the rear bumper of any automobile.

With such a vehicle it should be possible to compare directly data taken with different units at widely separated points or to compare data taken from time to time with the same unit. If this becomes possible, the usefulness of the relative-roughness indicator will be greatly increased.

Bituminous Materials and Low-Cost Road Investigations.—The bituminous investigations during the past year include: (1) Continued observations of experimental highways; (2) field surveys and related laboratory studies in connection with various types of low-cost roads; (3) development of provisional specifications for liquid asphaltic materials based on a standard simplified scheme of analysis; (4) laboratory investigations of bituminous materials and bituminous mixtures to aid in selecting suitable materials, and to develop satisfactory methods of design for special types of low-cost bituminous highway construction.

Of the experimental bituminous-treated roads constructed and maintained in cooperation with the highway departments of South Carolina, Nebraska, and California, two projects have been discontinued, and final reports are being prepared. The Nebraska experiments, which are of mixed-in-place construction in the sand-hill areas, are being closely observed, and a report of the construction and behavior of these sections is being prepared for publication. Periodic inspections of the bituminous surfacings on marl and sand-clay bases on the remaining project in South Carolina have been made, and the maintenance costs and behavior have been recorded.

Cooperation with representatives of the tar industry in field surveys of low-cost, tar-treated roads has been discontinued. The report of the survey of tar-treated roads in North Carolina has been published. A report of the observations of tar-bound roads in Pennsylvania is being prepared.

The cooperative effort of the Bureau, the State highway departments, and the asphalt industry to simplify the tests and standardize the specifications for liquid asphaltic road materials has resulted in provisional specifications for the principal grades of these materials. These proposed specifications have been considered by the cooperating agencies at a series of regional meetings, and they have been adopted in whole or in part by a large number of states.

This important work will be continued in the hope of Nation-wide standardization of specifications and test procedure for liquid asphaltic road materials.

Investigations to determine the weather-resisting properties of slow-curing liquid asphaltic materials from different refineries have been undertaken. This work is of importance since it is hoped that tests will insure the durability of this type of bituminous material which is used extensively in low-cost surfaces. A progress report of the work to date has been prepared. Similar materials from other refineries, as well as liquid asphaltic materials of the rapid-curing type and tars from various producers, are to be studied during the coming year. The development of a satisfactory accelerated laboratory test, to supplement the tests more commonly used for the control of quality of liquid bituminous products, should aid greatly in securing longer life and greater durability of the materials.

Laboratory investigations to determine and evaluate the factors essential to the proper design of hot bituminous paving mixtures have been continued. These investigations involve tests of laboratory and field samples both with the Hubbard-Field stability apparatus and with the roller stability machine designed by the Bureau to stimulate the action of traffic. A progress report is now being prepared.

There has recently been built for testing purposes a small circular test track having an outside diameter of 14 ft. and a width of 18 in. Facilities are provided for temperature control, and provisions are made for variations in the type and condition of the base. Traffic is applied to the test surface with full-sized rubber-tired automobile wheels. This permits the testing of low-cost bituminous surfaces under controlled conditions which are essentially comparable to those of actual service. To date, the effect of various quantities and consistencies of the bituminous material in mats of the road-mixed or plant-mixed types, has been studied. As the work progresses, tests will be made to determine the relative importance of other factors influencing the stability and durability of the different types of low-cost bituminous surfaces, such as type of bituminous material, type and grading of mineral aggregate, and character and condition of the base.

Subgrade Investigations.—Subgrade research work during the year has been conducted principally as follows: (1) Simplification of the routine procedure for testing soils; (2) adaptation of the principle of the drainage indicator to a new device for use in testing topsoils in the field; (3) investigation of the relative efficiency of various preventive measures in common use for overcoming the detrimental effects of subgrade heaving due to frost; (4) investigation of the compression test of soils for practical use in connection with the design of foundations for bridges and other structures; and (5) development of new tests to disclose the properties of soils stabilized by chemical admixtures and other methods.

In the routine procedure for testng subgrade soils, described in *Public Roads,* vol. 12, nos. 4, 5, 7, and 8, there were included tests sufficient in number and sufficiently varied in character to identify all of the various soils likely to be encountered in a national highway-construction program and to allocate them to the proper subgrade group indicated by their physical characteristics.

Much of the soil testing is now performed to determine the suitability of soil or soil material for some particular use as, for instance, binder in sand-clay and gravel roads, filler in bituminous road surfacing or soil in mud-jack operations; to distinguish between the good and the undesirable varieties of individual groups of surfacing materials such as limerock, caliche, shale, and to identify the properties of various materials which, as admixture, may assist in the stabilization of both subgrades and soil road surfaces.

Generally the efficiency of particular materials for the special uses just mentioned depends upon the presence of several of the half dozen or more physical characteristics investigated in the complete testing procedure. Therefore in the study of special materials, the testing procedure is limited to the use of tests which disclose the particular characteristics on which the performance of the special material depends.

Studies of this character consist of three distinct steps as follows: (1) Analysis of the requirements of the material for the use intended; (2) determination of the dominating characteristics satisfying these requirements; and (3) selection of the particular tests best suited to furnish the desired information with regard to these dominating characteristics.

The drainage indicator, developed to furnish the designer with tangible evidence of the drainage properties of soils, was discussed last year. As a further utilization of the principles controlling tests with this apparatus a new device has been designed for field use. This device, termed "the combined soil tester," gives information as to permeability, capillarity, and stability of the soil sample. It was designed primarily for use in prospecting for topsoil and sand-clay road-surfacing materials.

As research has developed information with regard to the causes of frost heave, the locations where it is apt to occur, and possible methods of elimination, various preventive measures based on this information have been utilized in road construction. Surveys in regions where frost heave is a serious problem have now been made to determine how well the preventive measures have performed their intended functions. The resulting information will serve as a basis for recommendations guiding the construction of roads where conditions indicate the possibility of frost heave.

The practical significance of the Terzaghi compression test as a means of disclosing the effect of proposed loads on the performance of soft undersoils was determined from a comprehensive investigation of the hydraulic fill at Four Mile Run on the Mount Vernon Memorial Highway. In this research settlements of the fill as determined by levels, and moisture contents of the soft undersoil as determined from samples in the laboratory, were compared with corresponding settlements and moisture contents as computed from data furnished by compression tests on samples of soft undersoil in the undisturbed state. The agreement between computed and observed values seems to show that the settlement of soil layers in the field follows much the same laws that control the consolidation of small soil samples in the compression test in the laboratory.

In new tests to disclose the suitability of low-cost road

materials, an attempt is being made to arrange for the testing of the entire sample, including coarse, as well as fine material; for the preparation of the sample by bringing it into a state of consolidation similar to that attained by such materials when used in low-cost road construction; and for the testing of the sample directly for the properties on which the service of such materials depend.

In the current laboratory procedure the binder fraction (passing the no. 40 sieve) is tested for several physical characteristics such as permeability, shrinkage, and water absorption. The mechanical analysis of the soil mortar (passing the no. 10 sieve) is determined. The coarse fraction (retained on the no. 10 sieve) is tested for grading, hardness, etc. From the results of these three sets of tests an estimate is made of the value of the materials for the use intended.

These tests are satisfactory for fine-grained subgrade soil, but they do not satisfactorily indicate the properties of soils containing only a small percentage of fine particles. They are also inadequate in showing the effect of admixtures incorporated for stabilizing purposes. Investigation will be made of the suitability of tests in which the sample is mechanically consolidated to a density representative of that produced in a soil road surface by traffic.

In these tests the entire sample, including coarse fractions, is to be brought to a state of optimum consolidation, and then tested for permeability, capillarity, stability, and shrinkage.

Cooperation with the State highway departments in the making of subgrade surveys, in the design of the subgrade treatments and road surfaces, and in the establishment of subgrade soil laboratories, has continued as in past years.

Production Cost Studies

Road Construction as an Employment Measure.—The use of highway construction as a means of furnishing employment for idle labor has emphasized the need of more precise knowledge of the amount of human labor entering into each of the various road building and maintenance operations, and how and to what extent the labor element varies when different methods and equipment are used. The collection of data bearing on these questions, in terms of the number of man-hours required to produce a given result, has been made a regular part of the production-cost studies.

Last year a study was made of the extent to which labor profits from the construction of high-type pavements in which mechanical equipment plays an important part. In this study the money paid out by states or communities for the construction of a concrete pavement was traced through its various exchanges showing how these expenditures extend to sand and gravel pits, stone quarries, cement and steel mills, to the manufacturers of equipment, repair parts, explosives, gasoline, lubricating oils, and supplies, as well as to railroad and transportation companies, and to those who furnish them their supplies, equipment, and repairs, which extend from coal and ore mines to mills and factories. When thus traced, it was found not only that about 90 per cent of the taxpayers' dollar was eventually paid to workers as wages and salaries, but also that a very large part of the industry of the country took an active part in the work and received a definite financial stimulus. A few more specialized studies have been made to show the extent to which particular industries or activities profit from normal highway work such for example, as the freight obtained by railroads as a direct and indirect result of highway-construction activities.

A study was also made to discover the trend of costs in highway construction apart from the influence of such factors as changes in use of materials, specifications, and construction practices. This study led to the development of a set of index figures based on the average cost of 1 mile of highway composed of units of grading, surfacing, and structures in the same ratios of use as were found in the highway-construction program for the years comprising the base period. This index, which was published in *Public Roads,* July, 1933, shows the trend in unit prices for excavation, surfacing, and structures, as well as for the composite mile of road improvement for the period 1922 to 1933.

The work in connection with carrying out the legislative provisions fixing minimum wage rates and maximum hours of employment on all road-constructon projects involving the expenditure of Federal road funds has been carried on in about the same manner as in the past, although the volume has increased considerably. As a regular part of this work, a monthly record of the number of persons actually employed in State and Federal road work is compiled.

Studies of Rolled Concrete Pavements.—During the past year studies were made on the placing of two sections of rolled concrete pavement using 5- to 7-ton tandem road rollers to consolidate a very lean and dry mix. In this work all methods of operation were practically the same as in the production of a standard concrete pavement, except certain operations behind the paver. The mix used was so lean that the mortar, while of about normal richness, was only sufficient in quantity to fill the voids in the coarse aggregate when the latter had been thoroughly consolidated by repeated passages of the tandem road roller. On both of the experimental sections a finishing machine was used ahead of the roller as a strike-off, although an ordinary heavy strike-off planer drawn by a winch on the paver would no doubt have been cheaper and apparently equally satisfactory for striking off the lean, harsh concrete mix at the desired height so that the consolidation produced by the roller would just bring the surface to the desired elevation. The second finisher was used behind the roller in the usual manner to spread such excess mortar as might be brought to the surface by the roller and to produce the customary smooth finish. With further experience in conducting the rolling and in designing the mix, this finishing machine may not be necessary, especially on secondary road work.

The rolling, which was begun immediately after the concrete had been spread and struck off, was carried on in much the same manner as in the construction of an ordinary broken-stone macadam surface and was continued until the surface was perfectly smooth and unyielding, and all the coarse particles were firmly interlocked and the mortar was just flushing to the surface. The regular grading of the coase aggregate as employed in the standard methods of construction was used in both cases, although there were some indications that a grading in which a considerable portion of the intermediate or finer sizes was omitted might prove better.

This method, while still in an experimental stage, seems to have considerable promise of development for use on secondary roads and in regions where sand and cement prices are high. Tests of cores and beams and general observations indicate that it will produce a pavement in point of surface smoothness, density, and both beam and compressive strength, comparing favorably with pavements placed by standard methods containing from 1 to 1½ more bags of cement per cubic yard. The studies will be continued with a view of determining the possibility of developing the method for use in the improvement of secondary highways.

Concrete From Central Mixing Plants.—Concrete for highway work is being supplied in increasing amounts

from large central mixing plants that are usually equipped with mixers very much larger than those of the portable type in common use on highway construction projects. Studies of two such plants equipped with 4- and 5-cu. yd. mixers indicate quite clearly that, with an actual mixing time varying from 1 to 4 minutes, little or no appreciable increase in either beam or crushing strength and no mprovement in the uniformity of distribution of the various ingredients throughout the batch are secured by mixing the batch longer than 1 minute. These tests also show that a grinding action takes place within the drum, the amount of which is directly proportional to the length of the mixing time. With the hard gravel aggregates used in these tests, the grinding was confined almost entirely to the sand, but with long mixing time the stone dust, or flour, thus produced was sufficient to have an appreciable effect on the slump. Thus, to produce a concrete of given slump, more water was necessary when the mixing time was long than when it was short.

Methods of Building Low-Cost Highways.—In view of the increasing difficulty of obtaining sufficient funds to provide and maintain adequate local highway facilities, considerable attention has been devoted to the development of the most efficient methods of building low-cost bituminous surfaces. Two types of such surfaces have been developed—the so-called plant-mix and road-mix types. In the construction of surfaces of the first type the stone and bituminous material are mixed in some form of mechanical mixing plant, either stationary or portable, in much the same manner as standard bituminous concrete. Surfaces of the road-mix type, on the other hand, are constructed by mixing the stone and bituminous material in place on the road.

The methods employed in both types of operation vary a great deal. There are hardly any two localities in which exactly the same methods are used; but everywhere the effort is being made to produce satisfactory dustless surfaces suitable for light traffic by methods and with materials less expensive than those employed in the construction of the higher types of bituminous surfaces.

The Bureau of Public Roads has joined in these efforts with studies of both plant-mixing and road-mixing methods. The studies of the plant-mix type have been devoted largely to finding means of maintaining production rates in the face of a tendency to add refinements which jeopardize the essential low cost of the product. In the case of the road-mix type its work has been mainly a search for ways and means of simplifying and standardizing construction procedures and developing more effective and efficient mixing equipment. Progress along these lines has been gratifying and gives promise of definite results.

Grading Studies.—The changes that have taken place in recent years in grading practices are most striking. In 1926 the power shovel in use on the average highway-grading job in the United States had a dipper rated at ¾-cu. yd. capacity and the 1¼- or 1½-cu. yd. horse-drawn wagon was the prevailing hauling equipment. Today the Bureau of Public Roads' studies indicate that the average grading job is equipped with a shovel having a dipper capacity of 1¼ cu. yd., and that the 1½-yd. shovel is now more common than the ¾ yd. Horse-drawn hauling equipment is now seldom seen, the prevailing type of hauling equipment being the heavy truck or large tractor-drawn wagon. A series of articles entitled "Power Shovel Operation in Highway Grading," has been revised and rewritten for publication in the near future.

The bulldozer has long been standard equipment on the dump and in building sidehill trails and minor roads. Recently the use of the bulldozer has been successfully extended to the longitudinal movement of earth and all loose or friable materials in regular highway-grading work. Studies of the operation of this type of equipment indicate that it should find considerable use in connection with the power shovel whenever the topography is broken or rugged and the hard rock is overlain by a considerable mantle of earth, deeply decomposed rock, or other friable materials. The essential requirements for successful use of the bulldozer as a grading unit are steep surface grades, relatively short hauls, and a material of which a load can be accumulated readily. If the material is hard, scarifying or blasting must be resorted to before the bulldozer can operate efficiently. Hard rock or hard shales can seldom, if ever, be fragmented sufficently even by heavy blasting to make the use of the bulldozer economical. This type of material should be reserved for movement by the power shovel.

Studies of use of the elevating grader in highway work indicate that recent improvements—among them the provision of a separate power unit for operating the elevator belt—have extended the field within which this type of equipment may find profitable employment to include very slippery and very loose and sandy soils, in which operation was formerly impractical or impossible because of bullwheel slippage. Broadly speaking, however, the field of the elevating grader is still limited to the movement of earth reasonably free from roots and stones in level to gently rolling county. In a recent study, five elevating graders were observed working under favorable conditions in ground of this type for all of which the production average over 200 cu. yd. of pay material loaded, hauled, and placed in the fill per hour of actual operation.

Highway-Accounting Methods.—Accurate, complete and up-to-date information about the various activities of a highway department is essential to efficient and economical administration and control. The Federal Government is vitally interested in the attainment of the highest possible degree of efficiency in the various State departments with which it cooperates in the construction of Federal-aid roads. For these reasons, the Bureau has continued the effort to further the development and installation of efficient accounting and statistical procedures that will provide the State administrative and engineering organizations with full and complete records of current income, expenditures, and accomplishments in highway construction, maintenance, and administration, and by their uniformity permit the accomplishments of one State to be fairly compared with those of another. Such a comparison is as yet largely impossible, except in a few States, because of the dissimilar form of the available records and the lack of a uniform nomenclature and procedure. The aim is to provide a system of accounts and records that will be economical in operation, will fully meet all accounting requirements of the department, and will provide quickly and in practical form complete statistical information on any desired activity in which the department is engaged. Cooperative work along these lines was carried on during the past year with the State highway departments of Arkansas, New Hampshire, and Indiana.

Transportation and Economic and Statistical Investigations

Michigan Traffic Survey.—The report of the traffic survey conducted in Michigan in cooperation with the State highway department in 1930 and 1931 was published in the February 1933 issue of *Public Roads*. Among the more important results of the survey was the determination of the relative utilization of the State highway system, the county and township highways, and city streets. The survey revealed that 50 per cent of all Mich-

igan traffic is carried by the streets of cities in the state, 5 per cent by the township roads, 12 per cent by county roads, and 23 per cent by the State highway system.

On the 7,691 miles of main roads included in the State highway system the average daily traffic was found to be 1,144 vehicles. On the 17,175 miles classified at the time of the survey as county roads the traffic averaged 190 vehicles daily, and on the 60,214 miles of township roads, most extensive and least important of the State's road mileage, the traffic averaged only 22 vehicles per day. On 25 per cent of these roads the survey showed the traffic to be 10 vehicles or less daily.

Of the traffic on city streets 69 per cent was found to be local to the city, and 31 per cent was found to originate at, or destined to, points beyond the city limits. As an incident of the survey it was found that 2½ million motor tourists visited the State during the survey year with estimated total expenditures of $274,000,000. Over 80 per cent of these tourists were found to be from neighboring states and Canada.

Washington Regional-Area Traffic Survey.—Field work of the Washington regional-area traffic survey was finished in September, 1932, and a report is now in preparation. Traffic information will be available in sufficient detail to serve as the basis for development of a connected system of main highways in the Washington regional area and to indicate desirable priority of construction. A complete analysis has been made of the necessity for the construction of several alternate routes, including bridges, to relieve congested existing routes, and studies have also been made of possible relocations and extensions of several existing highways. The data are sufficient to indicate with reasonable accuracy the minimum volume of traffic which would be carried upon the proposed new routes. It is believed that it will be possible to make recommendations, the adoption of which will result in greater economy and convenience to traffic upon certain of the projected routes, and in large savings in right-of-way and construction costs by modification of prior proposals that have not been based upon factual information with regard to traffic movements.

Indiana Traffic Survey.—As the fiscal year closed, field work on a 12-month survey of traffic in 11 representative counties of Indiana was nearing completion, being scheduled to terminate in August. As the first comprehensive traffic census ever made in Indiana, its results, showing relative proportions of foreign and domestic traffic on township, county, and State roads will be of importance to State authorities. A report of the survey will be started upon completion of the field operations.

New Jersey Traffic Survey.—A survey of traffic upon the entire State highway system of New Jersey and upon a limited mileage of the principal county routes was made. The resulting report will contain data on the origin and destination of truck traffic, the nominal capacities and body types of trucks, their classification as owner operated, contract haulers, or common carriers, and as of interstate or intrastate operation, the origin and destination of all vehicles observed at the Hudson River and Delaware River crossings, and the determination of the proportions of passenger-car traffic upon each of the highway systems that are local to each county or that originate in other areas. Special studies will be made of the data in connection with the necessity for additional highway facilities in the State.

Traffic Capacity and Intersection Studies.—Research has been continued into the efficiency of various types of traffic control at highway intersections. A large number of vehicles have been electrically timed through intersections of different types, and data for comparative study have been obtained by the experimental varying of signal cycles or the making of observations before and after the inauguration of new control systems.

Observations of traffic on United States Route No. 1 between Jersey City and Newark, N. J., made in connection with the traffic survey in that State, have indicated that the new high-level viaduct is saving highway users approximately 1 million "vehicle-hours" per year. Speed of vehicles was determined by the recording of license-plate numbers and time of passage at both ends of the route, before and after its improvement. The results of these observations will be published.

Tests of Highway Signs.—Tests to determine the relative efficiency of reflector buttons designed for use in highway signs and the attention-arresting values of sign color combinations, undertaken in cooperation with the Bureau of Standards at the request of the American Association of State Highway Officials and the National Conference on Street and Highway Safety, have been completed. This investigation involved the determination of the personal acuity and rapidity of perception of 121 individuals as measured by a tachistoscope adjusted to control definitely the time interval of free observation. The conclusions reached indicate that black letters on a yellow background are more easily read than black letters on white background or white letters on black background, and that a reflecting button with a diameter of 0.76 in. is relatively more efficient for rural use than reflecting units of 0.95 or 0.58 in. This advantage is not so apparent under conditions usually obtaining in city streets where the absence of glare under dimmed headlights increases the value of the small button.

Uniformity in Motor-Vehicle Regulations.—The complicated situation resulting from the diversified motor-vehicle legislation existing in the 48 States and the District of Columbia was studied, with representatives participating in several conferences of State administrators and vehicle-operators' associations. The entire problem of motor-vehicle regulation was analyzed in a report published in the December, 1932, issue of *Public Roads.* Movements toward greater uniformity in State legislation have been launched in various parts of the United States, and the Bureau has been lending its cooperation to these efforts.

Studies of Taxation in Wisconsin, Michigan, and Illinois.—Results of extensive inquiry into the finances of Wisconsin, Illinois, and Michigan with special reference to highways were made available to the public in the April, May, and June (1933) issues of *Public Roads.* All three studies related to the calendar year 1930 as the latest year for which complete data were available. The purpose of the investigations was to establish the relation of highway taxes paid from different sources and by different groups of citizens, based on local administrative units and the highway service furnished, and to lay down a broad basis for adjustment of highway taxes on a rational plan.

Many important facts regarding highway financing may be adduced from these surveys. In all three of the States covered, it was found that the rural property paid no tax for urban streets, but a part of the tax on urban property was expended on local township roads. A striking similarity was found to exist between the proportion of motor-vehicle imposts paid by rural and urban motor-vehicle owners and the proportion of highway travel by these owners; for example, rural motor-vehicle owners (residents of townships) in Wisconsin paid 33.9 per cent of the total motor-vehicle imposts expended on all classes of roads and streets, and travel by these same rural owners made up 31.9 per cent of the total travel on all classes of roads and streets, while the corresponding percentages for city and village motor-vehicle owners were, respectively, 66.1 and 68.1 per cent.

Developments in Highway Surfacing Using Asphalt

By Bernard E. Gray

Highway Engineer, The Asphalt Institute

FOR the past 15 years the highway builder has been about a mile behind the builder of the motor vehicle, because of inability to fully evaluate the conditions to be met on the highway by the time it would be completed. This is probably only natural, as an improvement in motor vehicle design can be translated into an actual machine in a few months' time, whereas the improvement of thousands of miles of highways requires a number of years. It is more accident than planning, however, that the cycle of events in the design of vehicles and highways is now resulting in the road builder being able to produce at reasonable cost a sufficient mileage to take care of all future expansion of growth of the motor vehicle.

A Gravel Road-Mix Surfacing in New England, Using Cutback Asphalt

Fifteen years ago the motor vehicle was increasing in weight and in speed, and the damage which it did to a road surface was increasing in proportion. To meet this load the highway builder was constructing heavy expensive pavements and had the design of motor vehicle continued along these original lines, it would have been difficult if not impossible to have provided an adequate highway system for their use and the total number of motor vehicles would never have reached its present proportions. The fact that the road did not keep up with the vehicle led the designer of the latter to use metal alloys of lesser weight, smaller engines operating at higher speed, and balloon tires which gave greater cushioning power. It slowly dawned upon the highway builder that many of his light roads which had been waterproofed with bituminous treatments were often satisfactorily carrying these new vehicles, were not wearing out as rapidly as before, and that under good subgrade conditions were equal to expensive pavements in supporting power. Greater attention was given to the building of a smooth road surface, which still further increased the capacity of light road surfaces, lessened maintenance and greatly extended their useful life.

Today there are several new developments in the design of the motor vehicle which will further change our ideas in regard to comfort of vehicle operation and may lessen the need for extreme care in obtaining super smooth surfaces. Reference, of course, is made to the separate wheel suspension, the complete air-cushion tire, and the so-called air-flow body design to cut down wind resistance. These improvements, which undoubtedly will be applied to the great majority of cars operating on the highways a few years hence, will make it possible to maintain even thinner road surfaces (provided the surface is waterproofed so as to prevent mud and dust) because of load distribution over a greater surface area. Those who have seen the new light army tank having separate wheel suspension, operating at 60 miles an hour across a marsh on an even keel, have some idea of what is possible. These coming changes are not yet appreciated, but the potential savings in road construction and maintenance costs because of them are bound to be of large amount.

This brief review of design is given to show the necessity of paying very close attention to the future design of motor vehicles rather than blindly following precedents in the way of an orthodox design of highway surface predicted on past conditions. It is interesting to read again the articles by engineers of 15 years ago or even those of but 10 years ago, and to find how few of them had any thought of permanently maintaining certain types of surfaces. This was particularly true of surface treated roads or certain mixed-in-place types which were thought of as a temporary expedient to be used only until additional revenues were available, when they would be replaced by so-called permanent types of construction. Even the American Association of State Highway Officials carried the various mileages in their records of improved road surfaces without any particular designation for the so-called low cost group. No particular distinction was made between treated and untreated surfaces, and only old orthodox types were considered as durable in character. Table I is indicative of a changed attitude in this regard.

These various types of improved road surfaces are now being considered as definite types of improvement, equally well suited in their particular field to take care of traffic as compared with the most expensive types of surface, while the principle of stage construction is becoming thoroughly established as a sound procedure for any highway department.

One of the handicaps to the universal success of these low cost types of surface has been the tendency on the part of some engineers to go too far in the opposite direction. For a department which has been building nothing but 8 in. thick concrete or 12 in. thick macadam to suddenly decide that 2 in. of road-mix will meet any and all conditions is just as extreme as to use only the former designs for any and all conditions. There is, of course, the need for balance in design and for thorough study of traffic flow in order to know the conditions which must be met. Professor Ben Petty of Purdue University pre-

TABLE I—STATUS OF STATE HIGHWAY SYSTEMS IN THE UNITED STATES

(Improved or Under Construction as of January Each Year)

	Low Cost Types				
Year	Earth	Sand-Clay	Gravel	Waterbound Macadam	Bituminous Mix
1929....	40,266	14,186	75,356	11,128	..... (A)
1930....	38,906	13,184	80,592	10,437	..... (A)
1931....	35,032	13,101	86,956	9,983	..... (A)
1932....	34,497	10,363	99,555	11,650	21,105
1933.... (C)	33,671	9,959	101,439	19,647	35,658

	High Types				
Year	Bituminous Macadam	Bituminous Concrete	P. C. Concrete	Brick	Unclassified
1929....	18,964	6,184	44,915	2,946	9,192
1930....	20,641	6,781	51,979	3,039	15,836
1931....	21,717	7,846	61,492	2,814	24,547
1932.. (B)	17,117	8,075	71,222	3,124	8,098
1933.... (C)	19,180	8,011	77,660	3,579	8,026

(A)—During 1929, 1930, 1931 bituminous mix surfaces were largely unclassified, but were approximately 2,500, 6,500 and 13,000 miles, respectively.

(B)—Shows replacement of a certain mileage of very old surfaces with other types, followed in 1933 by a substantial increase again as result of experience with modern methods.

(C)—Shows strikingly the increase of low cost types. Sand-clay and waterbound macadam are nearly all bituminous treated and gravel mileage about 30 per cent surface treated.

sented one of the best discussions on this subject in 1933 entitled, "They Stopped Too Soon," in which he stressed the need for carrying through to ultimate completion any variety of construction, no matter how inexpensive, so as to obtain full utility from the expenditure. He noted in one part of his paper, the fact that many miles of road-mix roads had been constructed in the last two years upon inadequate foundations and that it would be expecting the impossible for these surfaces to last with further reinforcement. One of the inconsistencies in design still found in many quarters is the fact that for an expensive type of surface the most complete drainage and foundation preparations are made, but if the surface is to be a thin bituminous type, drainage is often completely neglected and but little attention is given to proper subgrade preparation. One of the present needs, therefore, is proper evaluation of the requirements for different types and for wider dissemination of knowledge in this regard.

Asphalt is used in all types of construction. The earliest use of the material was almost exclusively in the high type surfaces, such as sheet asphalt, asphaltic concrete and asphalt macadam, but the adaptability of the material to the low cost types has been so conspicuous that for several years attention has been directed largely to such use, even though the other types also have made much progress. These various types may be grouped in the order of their usual cost which also happens usually to be in the order of increasing traffic capacity as well.

A Surface Treated Gravel Road in Virginia, Using Cutback Asphalt.

A Modern Penetration Macadam Road in Massachusetts, Open Texture Type.

1. Surface treated macadam, gravel, sand-clay, limerock, shale, chert, etc.
2. Road-mix or cold-laid plant-mix using liquid asphalt products.
3. Asphalt macadam (penetration type).
4. Hot-mix surfaces such as sheet asphalt, asphaltic concrete, asphalt block, laid hot or cold.

Surface Treatment.—As previously noted surface treatment is now being recognized as a definite design. The Bureau of Public Roads, for example, now requires that where a surfacing of stone or gravel, or equivalent material, is to be placed on a Federal aid project, provision shall also be made at the same time for a bituminous surface treatment. This policy is but a clear recognition of the economy of preserving the road surfacing materials and the durable character of such improvement, to say nothing of the increased comfort and utility of the road to traffic.

The one single outstanding improvement in asphalt surface treatment has been the use of a new asphalt primer having very high penetrating and hardening characteristics. This primer belongs in a class of liquid asphalt products which is being rapidly introduced in the eastern part of the country and which has had a wide development on the West Coast, viz., the medium-curing cutback asphalts. In the East most engineers have been familiar with naphtha cutbacks or the so-called rapid-curing liquid asphalts. The medium-curing cutbacks are those wherein asphalt cement is dissolved in a distillate similar to kerosene and the penetrating powers of the combination are substantially those of kerosene. Using this asphalt primer it is possible to consolidate and harden even the dustiest and finest sized aggregates to produce a stable condition and so that a seal coat of more viscous asphalt material, such as rapid-curing cutback emulsified asphalts or hot asphalt cements, can be applied later with

the assurance that a complete bond will be developed and that pot-holing will be practically eliminated.

Accordingly for an original treatment, specifications should require that the surface shall first be given an application of asphalt primer, or as it is better known, MC-1 Liquid Asphalt, as specified under the U. S. Bureau of Public Roads Specifications. The amount of prime to be used will depend upon the character of the surface to be treated. If it is of densely bonded character, such as well constructed waterbound macadam, sand-clay, limerock, or clay gravel, then the rate of application will be usually from one-quarter to one-third gal. On the other hand, if it is a loose gravel or chert, cinders or a loose traffic-bound macadam, then the rate of application will range as high as one-half to three-quarter gallon per square yard. Enough should be used so as to absolutely kill the dust, and to cement the fine particles together into a uniform condition of surface. After this priming operation, it is desirable to allow traffic over the surface for several days so that any loose areas will develop and ravel out and then be repaired by making suitable patches using the same material of which the road is composed and the MC-1 material. The seal coat then can be applied and may be of any of the usual asphaltic products as previously used in the particular locality. The outstanding and important development in surface treatment technique is that by using the asphalt primer for initial treatment, most of the difficulties which formerly attended surface treatment will disappear.

Another improvement in surface treatment methods (particularly in retreatments) which has obtained more recognition in the past year, is the fact that a definite relationship exists between the size of aggregate cover coat and the volume of asphalt applied. Because of inconvenience or because of inadequate specifications, many engineers have continued to use a single size aggregate and a single volume rate of application regardless of the condition of surface to be retreated. A little reflection will show that it must be obvious that in a single state, for example, where retreatment of surface will call for a program of as much as several thousand miles, it is hardly reasonable to believe that every mile will require exactly the same type of retreatment, and yet this is the policy that has been followed in many instances. Very material savings in cost of maintenance can be obtained by giving greater attention to the particular needs of the different miles of road under maintenance and in many instances retreatment can be deferred one, two, and even more years if situation is given greater study. One reason for frequent retreatments has been a desire to maintain coarse textured surface.

A misunderstanding has existed with regard to the skidding characteristics of different surfaces and which fortunately has been exploded in the recent report of Professor Moyer before the Highway Research Board in 1933, in which he gave the results of tests on various types of pavement surfaces. As he put it, it is the so-called "sand-paper" finish which gives a high coefficient of friction and not necessarily large size aggregate. Quite coarse aggregate may be often highly advantageous, particularly in areas where sleet conditions are encountered, but in many other sections only a light waterproofing is required to conserve pavement values, in which case a small application of liquid asphalt and a smaller cover coat aggregate will give equally high coefficients of friction and anti-skid qualities. It may be said without any fear of successful contradiction that too much bituminous material per square yard is often employed. Only enough should be used to insure a uniform covering of the surface, except where definite additional thickness is required in order to produce greater strength, and in which case different methods usually should be employed other than those ordinarily followed in simple retreatment operations.

Objection to using different size aggregates is sometimes advanced on the ground that aggregate producers do not make the different sizes, or that it is inconvenient. The answer is that producers make whatever is demanded, and that if costs of retreatment can be cut in half it pays for quite a lot of inconvenience. The following table shows approximately the relation of quantity of asphaltic material and size of aggregate cover to be used. It is to be noted that it is perfectly possible to

A Road-Mix Surface on a New York Highway.

give a retreatment of as little as one-tenth gallon per square yard provided correctly sized cover coat material is employed, and yet have a completely non-skid surface. The proper design is to have a dry surface with all aggregate cemented to the road surface.

QUANTITY OF ASPHALTIC MATERIAL AND SIZE OF AGGREGATE COVER

Gallons Per Square Yard	Size Aggregate Inches	Pounds Per Square Yard
0.1	⅛ × ¼	10
0.2	¼ × ⅜	20
0.3	⅜ × ½	30
0.4	½ × ¾	45
0.5	⅝ × 1	55

N. B.—Exact grading limits will of course extend beyond those given above, but the nearest commercial size should be selected that will have about 75 per cent of particles within above limits.

Road Mix Types.—Probably no type of road surfacing has received as much attention as the cold-laid mixes which may be either the road-mix type or the plant-mix type. The great popularity of this variety of surface has developed because of the extremely smooth-riding qualities which are obtainable using such universal equipment as road graders and road drags and the rapidity of construction operations. The types are not new in the past year but they have received further refinement in construction technique, and there is unquestionably a growing trend toward the plant-mix method as contrasted with the road-mix method. This choice of method depends upon a number of conditions and a discussion of the subject by C. S. Pope, Construction Engineer, State Highway Department of California, presented last year, is one of the best yet given. He summarizes the different factors to be given consideration about as follows:

"In deciding as to design of mixture these questions arise:

(a) What are the characteristics of aggregates which will make the most successful asphalt mixes?
(b) What are the characteristics of a suitable aggregate and in what proportion should they be used for the best results?
(c) What is the correct method of determining the

percentage of asphalt to be applied and how may uniform results in mixture be secured?

(d) What are the proper asphaltic products to be used in different climatic conditions or with materials of different grading?

Then after the design has been made, the choice of method comes up for decision and the following questions are to be considered:

(1) Does the comparison of the factors determining the choice between road mix and plant mix for bituminous treated aggregates apply to surfaces of equal durability, thickness and width, supported by such natural or prepared foundations as are necessary to sustain an equal traffic?

(2) Are the wage scales and hours of labor the same for the methods employed?

(3) Is the material of suitable grading at present available in the road, or must it be provided?

(4) Which method of construction is best adapted to minimize the effect of rainfall on the aggregate or on the resulting surface during construction?

(5) Which method of construction most nearly fulfils the requirements for accurate proportioning and control of materials?

(6) What methods of construction will give least interference with traffic and produce a satisfactory road surface at the least cost?

(7) Considering the aggregate available, what type of asphalt binder should we use to meet the traffic and climatic conditions, and can the binder selected be used with either plant or road mix equipment?

(8) Considering all the conditions, which method is least expensive?

Based on a study of California conditions, and for comparative purposes, we may assume the following conditions for an asphaltic mix:

1 in. compacted mix 20 ft. wide = 634 tons per mile
3 in. compacted mix 20 ft. wide = 1900 tons per mile
1,900 tons of mix will contain about 1,820 tons of aggregate and about 80 tons of asphaltic material.

Plant mix in California varies in price from $1.60 to $1.80 per ton laid with aggregate at about $1.00 per ton and asphaltic material at bout $10.00.

Data from various states and from our own records indicate that road mixing a 3 in. compacted surface varies in cost from $500 to $700 per mile.

For road mix, therefore, we have:

1,820 tons of aggregate at $1.00	$1,820
80 tons of asphaltic material in place, at $15.00	1,200
Mixing at, say	600
Cost of 1,900 tons of road mix	$3,620
Cost of 1,900 tons of plant mix at $1.80	$3,420

From the above very rough comparison, it is apparent that, unless road mix costs are very much reduced, there appears to be no saving in that method over the use of plant mix material where the project is of sufficient size to justify plant installation."

This would seem then to be the criterion. For short jobs or where ample aggregate is already on the road surface, road-mix methods are preferable; for long jobs or where new aggregate must be added, the plant mix method is indicated. Mr. Pope's discussion applies particularly to the graded aggregate type, but the principles apply equally well to the macadam aggregate varieties.

Some confusion still exists in the minds of a number of engineers as to the fundamental principles underlying cold-mix construction. There are two distinct varieties of cold-mix surfacing and many mistakes of construction will be avoided if engineers will familiarize themselves with these principles and not try to apply bituminous materials designed for one class of aggregate to those of the other. One is the macadam aggregate type, wherein the smallest aggregate particle is ¼ in. or greater in size and ranging from that up to 1½ in. in the maximum size. This kind of aggregate should be coated with a rapid-curing asphaltic material which remains liquid only for a sufficient period so as to provide for proper manipulation, after which it should revert to a relatively hard asphalt cement. Such a surface depends for its stability upon the interlocking of the aggregate particles which are held firmly in place by the cementitiousness of the asphalt.

As contrasted with this type, there is the graded aggregate type wherein the particles range from a maximum of 1 in. down to and often including a substantial amount of material passing a 200 mesh sieve. The bulk of the material passes a ten mesh sieve and is, therefore, essentially of sandy character, as contrasted with the definitely coarse aggregate character of the first group. The graded aggregate mixture depends for its stability on the filling of the voids in the mixture,—there being relatively little interlocking of the aggregate particles. A greater amount of asphaltic material is usually required for the second type of construction than for the macadam aggregate type because the surface area of the material to be coated is much greater using fine aggregates. Furthermore, in this graded aggregate type a medium-curing asphalt is required because of the greater penetration required to thoroughly coat all of the fine particles and because of the desirability of reworking the surface in the event of any deformation due to changing subgrade conditions. Accordingly the graded aggregate type is particularly adapted to round gravel aggregates, while the macadam aggregate type is utilized with crushed aggregates.

In a plant-mix of either type, higher viscosity asphaltic products, viz.: those with quicker setting properties, can be used as only time for manipulation to spread and smooth the surface is required as contrasted with a much longer period of time needed in the road-mix. The essential difference, however, regardless of whether it is a road-mix or a plant-mix, is that in the macadam aggregate type a rapid-curing liquid asphalt is desirable while in the graded aggregate type a medium-curing liquid asphalt is best suited. These asphalts may be either of the cutback asphalt or the emulsified asphalt variety, and different viscosities are available to fit both variations in aggregate character and climatic conditions.

Penetration Macadam.—Penetration macadam was one of the earlier types of bituminous road surface employed in the United States, dating back some 25 years, and widely used in New England and New York. The practice of using a soft asphalt seal coat on a high crown cross-section brought the type into disfavor for a period, but the recent changes in design, so as to produce an open texture surface on a flat crown, now makes it one of the most favored types in Massachusetts where it is used for the very heaviest traffic conditions. For construction with hot asphalt cement, it is highly desirable that very hard and tough stone should be used for aggregate, a condition which is most easily met in the north where traprock is abundant. This change in design so as to have an exposed stone surface on which the traffic wear comes, in place of the former rich seal coat of soft asphalt cement, is of great importance. The rewriting of specifications everywhere to conform with this new principle is strongly urged as it will make all of the difference in the world as to the character of final road obtained. These essential differences are shown in the following table:

PENETRATION MACADAM DESIGN

Modern Method (*2.4 gals. asphalt per sq. yd.*)	*Old Method* (*3.0 gals. per sq. yd.*)
1. Layer of coarse stone to produce 2½ in. compacted depth.	1. Layer of coarse stone to produce 3 in. compacted depth.
2. Application two gallons asphalt cement, and light cover ¼ in. × ¾ in. crushed stone thoroughly rolled.	2. (a) Application of 1¾ gals. asphalt and cover coat 1 in. stone. (b) Application of ½ gal. asphalt and cover coat ¾ in. stone.
3. Application ⅜ gal. asphalt cement and sufficient ¼ in. × ¾ in. stone to fill surface voids only and rolled.	3. (a) Application of ½ gal. asphalt and cover coat ½ in. stone. (b) Application of ¼ gal. asphalt and ¼ in. stone.
Coarse open texture.	Flush, closed texture.

Hot-Mix Surfaces.—Hot-mix surfaces are among the highest types of road surface construction, and for city streets sheet asphalt and asphalt block continue to be the most popular and widely used types in the East, with asphaltic concrete similarly popular in the West. The important development in this field in recent years has been the rapidly extending use of coarse graded asphaltic concrete in rural highway construction, both as a salvage medium over old foundations which have reached the end of their usefulness, and also for entirely new construction. As a general proposition, well constructed asphaltic concrete does not need to be as thick as rigid types because of its elastic character which permits of adaptation to slightly changing subgrade conditions. Under normal subgrade conditions of stabilized character, a 3 in. base course and a 2 in. wearing course will give all the structural strength required to carry the usual traffic. In Massachusetts, for example, in the Cape Cod area, this total thickness is reduced to 4½ in., using a 2½ in. base course and a 2 in. wearing course.

A number of states are now revising specifications to conform to new developments but all states would do well to include a number of new requirements which have been found essential for good construction, and which, strange to say, at the same time will reduce the cost to the contractor. The requirements for adequate plant capable of turning out a mixture in real accordance with design is of great importance, while the use of mechanical finishing machines on the surface should be made mandatory. It may sound strange to imply that paving plants do not always turn out the mixture set forth in the specification, but it is a fact that the average specification permits of such wide variations in the grading of aggregates that even with good inspection the plant itself cannot be controlled as to the character of the finished product. This has resulted in non-uniform results and consequent difficulty in obtaining perfect surfaces. The adoption of a new type of specification such as the Ohio T-50, for example, is a real advance in securing adequate control so that a uniform product may be turned out and at a lower cost because of eliminating delays. To illustrate how sketchy have been some of the old requirements, it is suggested that the engineer turn to his specifications and count the pages devoted to portland cement concrete and then count the pages devoted to asphaltic concrete. It is quite to the credit of cement concrete construction that improvements over the years have necessitated this space to be devoted to a great variety of minor details, all of which contribute to the general smoothness of the finished work. The producers of asphalt hot-mix construction are rapidly adopting similar provisions so that in addition to the qualities of elasticity and durability, it is now easy to obtain a perfect smoothness of surface, as well as lowered costs and greater speed of operations by having the details of construction technique equally well set forth.

There are one or two basic requirements in plant-mix construction. In the past there has been altogether too great a tendency in resurfacing operations to endeavor to lay a single layer of hot-mix regardless of the uneven condition of the old surface. There have even been construction jobs where the widened areas and the resurfacing were attempted all in one operation with a variation in thickness ranging from as much as 9 in. at the edge to 1¼ in. in the center. Obviously uniform compaction and uniform density are impossible under such conditions. The following steps, therefore, are essential: Widened areas should be filled with the coarse graded asphaltic concrete only to the level of the existing pavement and then thoroughly compacted in place. A new machine for this purpose has been developed and was successfully used in a number of mid-western jobs during 1933. Next a leveling or wedge course should be laid, so as to take out the old crown, if any, and then so compacted as to produce a uniform base section on which the top course may be laid. The top course then may be constructed of uniform thickness and consolidated with mechanical finishing and rolling to produce a uniform finish.

Summary.—The foregoing discussion of changes in methods and design are calculated more to stimulate thought along the needed lines of readjustment to meet the new traffic conditions, rather than a complete description of the procedure itself. They may be summarized as follows:

1. Road design has always lagged behind motor vehicle design, and greater coordination between the two should be brought about, so as to avoid unnecessary road costs.

2. The ability of relatively thin bituminous surfaces to carry even dense traffic is the most striking development in paving design, and further study in this field will yield large returns. Attention is particularly directed to a balanced program; the right surface in the right place. The so-called low cost types will meet over 80 per cent of the locations, the more expensive types in the remainder.

3. While much progress in selection of materials has been made, much more is needed. With a growing number of exceptions, many specifications (state, county and city) can be revised to advantage. Information available is not yet generally used.

4. In asphalt surfacing the following are the most recent developments:

(a) Liquid asphalt for priming purposes known as MC-1, to be used wherever consolidation and hardening of dust particles is required.

(b) That skidding is reflection of surface texture and not of materials, and that hard asphalt surfaces have generally the highest coefficient of friction under traffic, and consequently the greatest resistance to skidding.

(c) Improved specifications covering construction details, with great emphasis on relation of aggregate to asphalt. In general it is possible to reduce per cent of asphalt per unit of mixture with improved durability and lower costs.

(d) Trend toward plant-mixing, using larger plants with more accurate controls.

(e) Rapidly increasing use of mechanical finishers, and which should be made mandatory wherever practicable.

In conclusion, it may be safely said that the highway building era in the United States is not ending, but is only beginning. Through use of more low cost surfaces plus a vastly improved motor vehicle, the roadbuilder will be able to coordinate his design so that even with stabilized revenues, he can build five miles of improved road where only one was possible before, and there extend markets to areas which are as yet new territory.

State and County Highway Construction in 1933 and 1934

Reports from Highway Officals Showing Probable Expenditures

New England States

Rhode Island

The State Board of Public Roads will have available for 1934 state funds of $1,000,000 for construction and $875,000 for maintenance. The NRA funds available for 1934 for construction amount to $2,000,000. The highway completed in 1933 included 11.7 miles of portland cement concrete, 17.1 miles of bituminous macadam and 40.6 miles of bituminous surface treatment. Details follow:

STATE HIGHWAY COMPLETED IN 1933 IN RHODE ISLAND

Types	Miles	Average Width Surface Ft.	Thickness, Inches	Estimated Av. Cost Per Mile
P. C. Concrete	11.7	30	8	$50,000
Bituminous Concrete	3.3	40	2½*	52,000
Bituminous Macadam	17.1	21	8	35,000
Bituminous Surface Treatment—Gravel	40.6	18	8	15,000

*On 6-in. concrete base.

The uncompleted construction carried over to 1934 was as follows:

UNCOMPLETED CONSTRUCTION CARRIED OVER TO 1934

Types	Miles	Estimated Total Cost
P. C. Concrete	10.7	$650,000
Bituminous Concrete	2.6	200,000
Bituminous Macadam	12.1	450,000
Bituminous Surface Treatment—Gravel	17.0	170,000

The probable construction in 1934 includes the following:

PROBABLE CONSTRUCTION IN 1934

Types	Miles	Estimated Total Cost
P. C. Concrete	1.1	$100,000
Bituminous Concrete	3.5	250,000
Bituminous Macadam	3.1	100,000
Bituminous Surface Treatment—Gravel	18.0	238,000

G. H. Henderson, Providence, R. I., is chief engineer, State Board of Public Roads.

Connecticut

The state highway completed in the 1932-933 fiscal year included 304 miles of gravel road and 53 miles of waterbound macadam. The types and other details follow:

HIGHWAY COMPLETED IN 1932-33 FISCAL YEAR IN CONNECTICUT.

Types	Miles	Average Width Surface Ft.	Thickness, Inches	Estimated Av. Cost Per Mile
P. C. Concrete	30.2	20	8	.....
Bituminous Concrete	....	20	8	.....
Bituminous Macadam	13.43	20	8	.....
Gravel	303.87	20	..	.....
Graded	....	20	..	.....
Waterbound Macadam	52.98	20	7	.....
Asphalt Concrete	2.68	..	..	.....
Rolled Stone	5.61	..	..	.....
Crushed Limestone	16.93	..	..	.....

The uncompleted construction carried over 1934 and its estimated cost are as follows:

Types	Miles	Estimated Total Cost
P. C. Concrete	14.81	$1,058,474
Bituminous Macadam	54.81	2,327,089
Gravel	40.02	240,830
Graded	5.14	201,652
Sheet Asphalt	4.66	616,402
Waterbound Macadam	14.61	304,239

It is not possible at this time to give a forecast of the 1934 new construction program.

John A. MacDonald, Hartford, Conn., is state highway commissioner.

Middle Atlantic States

New Jersey

The State Highway Department will have $7,250,000 of state funds available for 1934 for construction and $2,500,000 for maintenance. In addition there will be $3,300,000 of N.R.A. funds available for construction.

The state highway completed in 1933 included 28.5 miles 20 ft., 40 ft. and 60 ft., 9 in. and 10 in. thick concrete road at an estimated cost of $67,100; and 11.7 miles graded road, 40 ft., 90 ft. and 110 ft. wide at an estimated cost of $50,100.

The uncompleted construction carried over to 1934 was 62.5 miles of concrete road requiring an estimated expenditure of $7,700,000.

The probable construction for 1934 includes 37 miles of concrete at an estimated expenditure of $7,050,000 and 7.6 miles grading to cost $200,000.

Wm. G. Sloan, Trenton, N. J., is State Highway Engineer.

New York

State Highway Department awarded contracts in 1933 for 457 miles of construction at a contract price of $21,668,830. The department accepted 553 miles of road, costing $21,412,813.

East North Central States

Indiana

State highway work completed in 1933 included 231.6 miles of portland cement concrete, 20 ft. wide, 9-7-9 in. thick, at an estimated average cost of $21,075 per mile. In addition 10.88 miles of asphaltic macadam, 13 miles rock asphalt, 3.29 miles bituminous mulch (all 20 ft. wide) and 48.62 miles of graded road were completed.

The uncompleted construction carried over to 1934 included 83.67 miles portland cement concrete at an estimated total cost of $1,763,410, 13 miles gravel road, 8.38 miles graded road, 16.23 miles asphaltic macadam and 16.34 miles bituminous mulch.

The State Highway Commission proposes to expend approximately $18,000,000 for road and bridge construction and maintenance during the 1934 season.

M. R. Keefe, Indianapolis, Ind., is chief engineer, State Highway Commission.

Michigan

The types and mileage making up the 1933 surfacing program are as follows:

	Miles
20-foot concrete pavement	158
Concrete pavement widening	27
Gravel surfacing	62
Asphalt on gravel	18
Asphalt on concrete	1
Bituminous retread	6
Gravel surfacing	16
Stamp sand resurfacing	21

It is estimated that National Recovery contracts to the amount of $4,000,000 will be carried over to 1934. Approximately $6,500,000 of National Recovery highway funds will remain to be encumbered after Jan. 1st which will give the department an estimated construction program of $10,500,000 for the ensuing year. No state funds are available for construction at the present time and further comments upon the anticipated 1934 program other than the above cannot be made at this time. It is estimated that at least 50 per cent of 1934 construction will consist of high grade paving and not less than 35 per cent of grading, drainage and gravel surfacing.

Murray D. Van Wagoner, Lansing, Mich., is state highway commissioner.

Wisconsin

State highway contracts let in 1933 totaled 546 miles at a cost of $6,000,000. The 1934 is as yet indefinite except for $4,000,000 U. S. Public Works projects.

West North Central States

Minnesota

The State Highway Department will have approximately $8,000,000 of NRA funds for 1934 for construction purposes. In addition there will be approximately $4,500,000 of state funds available for maintenance. The state highway completed in 1933 includes 96 miles of portland cement concrete and 266 miles of bituminous surface treatment. Details follow:

STATE HIGHWAY COMPLETED IN 1933 IN MINNESOTA

Types	Miles	Average Width Surface Ft.	Thickness, Inches	Estimated Av. Cost Per Mile
P. C. Concrete	96.0	20	7.4	$1,605,941*
Bituminous Surface Treatment	266.6	30	..	956†
Gravel	243	..	..	182,250*
Graded	176	..	..	1,094,000*

*Total. †Approximate.

The uncompleted construction carried over to 1934 includes 15 miles portland cement concrete, 120 miles gravel road and 186 miles graded road. The construction program for 1934 has not been decided.

J. T. Ellison, St. Paul, Minn., is chief engineer State Highway Department.

Kansas

State highway work completed during 1933 included the following: Grading and culverts, 404 miles; gravel, 350 miles; bituminous mat, 437 miles; hard surface, 52 miles; bridges, 105. Total expenditure was $7,738,000.

The 1934 program at this time calls only for N.R.A. projects. These include 480 miles earthwork and culverts; 85 miles gravel road; three miles bituminous mat; 86 miles pavement. The total expenditure will be $10,089,604.

W. V. Buck, Topeka, Kans., is State Highway Engineer.

Iowa

The following is a brief review of the 1933 construction program of the Iowa State Highway Commission:

CONSTRUCTION WORK COMPLETED—1933.

	Miles
Paving	137.9
Treated gravel	4.8
Graveling	225.7
Grading	117.0
Bridges and culverts (structures)	884

CONDITION OF PRIMARY ROAD SYSTEM, DEC. 1, 1933.

	Miles
Paved	4,202.3
Treated gravel	139.2
Gravel	3,082.7
Graded	51.9
Unimproved	353.6
Total	7,829.7

UNCOMPLETED WORK UNDER CONTRACT, DEC. 1, 1933.

	Miles
Paving	89.9
Graveling	3.3
Grading	89.9
Bridges and culverts (structures)	353

SUMMARY OF 1933 EXPENDITURES.

Construction:	
Paving	$ 3,225,803.50
Treated gravel	96,764.91
Graveling	647,446.53
Grading	1,685,482.26
Bridges and culverts	949,535.31
Other construction	68,959.91
Right of Way	601,560.09
Engineering, administration, and inspection	721,837.95
*Refunds to counties	833,973.15
Miscellaneous expenditures	16,989.23
Total construction expenditures	$ 8,848,352.84
Total maintenance expenditures	2,668,974.18
Total const. and maint. expenditures	$11,517,327.02

*Reimbursing counties for expenditures made prior to 1927 for bridges, culverts and right of way required for the improvement of roads later included in the Primary Road System.

STATUS OF NATIONAL RECOVERY ACT PROGRAM ON DEC. 31, 1933.

A. Tabulation showing details of original program.

Item	Highway Projects	Municipal Projects	Secondary Projects	Total
Total Iowa allotment	$5,027,830	$2,513,915	$2,513,915	$10,055,660
Approved program:				
Paving	3,047,000	1,484,000	350,000	4,881,000
Treated gravel	351,000	91,000	119,500	561,500
Graveling	48,000	.....	49,000	97,000
Grading	1,311,000	49,000	1,942,500	3,302,500
RR crossing elim.	394,000	640,000	42,000	1,076,000
Special bridges	86,000	261,000	75,000	422,000
Total	$5,237,000	$2,525,000	$2,578,000	$10,340,000
Estimated additional cost of revised program	$ 957,000	$ 271,000	$ 55,000	$ 1,283,000
Estimated total cost of program	6,194,000	2,796,000	2,633,000	11,623,000
Amount under contract	4,419,000	1,111,000	598,000	6,128,000
Percent under contract	71	40	23	53
Estimated cost balance of program	1,775,000	1,685,000	2,035,000	5,495,000
Estimated state funds required to complete program	1,166,170	282,085	119,085	1,567,340

B. Construcion work involved to complete program.

	Miles	Estimated Cost
Paving	34.8	$1,073,000
Treated gravel	188.3	708,000
Graveling	31.0	53,000
Grading	274.9	2,308,000
RR crossing eliminations	*25	998,000
Special bridges	*10	355,000
Total		$5,495,000

*Number of structures.

Estimated funds available for construction work in 1934 in addition to amounted needed for completion of N.R.A. program are $1,500,000. No detailed program for the expenditure of this fund has been developed. Should additional Federal appropriations be made available for highway work, a part or all of this fund may be required to finance right of way costs in connection therewith.

North Dakota

The State Highway Department will have $5,500,000 of N.R.A. funds available in 1934 for construction and $1,200,000 of state funds available for maintenance this year. Over 1,200 miles of state highway were completed in 1933. This included 148 miles of bituminous mix, 645 miles of gravel and 486 miles of graded sand. Details of the 1933 work follow:

STATE HIGHWAY COMPLETED IN 1933 IN NORTH DAKOTA

Types	Miles	Average Width Surface Ft.	Thickness, Inches	Estimated Av. Cost Per Mile
P. C. Concrete	7.972	20	9–7–9	$30,000
Bituminous Concrete	1.4	24	4	21,000
Bituminous Mix	148.1	22	3	6,000
Gravel	645	21	6	1,200
Graded	486	24	..	3,360

The uncompleted construction carried over to 1934 included 6 miles of portland cement concrete, 15 miles of bituminous mix, 197 miles of gravel road and 353 miles of graded road.

The probable construction for 1934 includes the following:

Types	Miles	Estimated Total Cost
P. C. Concrete	7.0	.....
Bituminous Concrete	13.8	.....
Bituminous Mix	130	.....
Gravel	700	.....
Graded	600	.....

H. C. Frahm, Bismarck, N. Dak., is Chief Engineer, State Highway Department.

South Dakota

A considerable mileage of grading, graveling and bituminous surface treatment was completed by the state highway department in 1933. In addition 25 miles of portland cement concrete and 22 miles of bituminous mix were completed. Details follow:

STATE HIGHWAY COMPLETED IN 1933 IN SOUTH DAKOTA

Types	Miles	Average Width Surface Ft.	Thickness, Inches	Estimated Av. Cost Per Mile
P. C. Concrete	25	20	9–6–9	$24,000
Bituminous Mix	22	22	0–4–0	8,500
Bituminous Surface Treatment	113	22	0–4–0	6,000
Gravel	363	22	0–6–0	1,100
Graded	372	26	.....	4,050

The incompleted construction carried over to 1934 included 2 miles portland cement concrete, estimated cost per mile $31,000; 52 miles gravel road, $1,400 per mile; 66 miles graded road, $4,000 per mile. The probable construction in 1934 is as follows:

	Miles	Estimated Cost per Mile
P. C. Concrete	25	$28,000
Bituminous Surfact Treatment	400	6,500
Gravel	300	1,100
Graded	300	4,000

Gardner Gantz, Pierre, S. Dak., is State Highway Engineer.

Missouri

During 1933, the State Highway Department constructed:

295 miles Concrete pavement.
1,383 miles Gravel surfacing.
395 miles Miscellaneous surfacing.
1,715 miles Earth grading preparatory to surfacing.

The estimated value of this work is $23,786,000.

The unfinished portion of the active contracts carried over into 1934 include:

93 miles Concrete pavement.
254 miles Gravel.
40 miles Bituminous surfacing.
11 miles Miscellaneous surfacing.
486 miles Earth grading preparatory to surfacing.

The estimated value of this work is $7,900,000.

It is a little early to give a definite statement on the new commitments that will be undertaken in 1934. They will probably include:

243 miles Concrete pavement.
250 miles Gravel.
450 miles Bituminous surfacing.
45 miles Earth grading preparatory to surfacing.

The estimated cost of this new work is about $12,000,000.

These figures are subject to revision after further study and consideration of financial resources. The legislature has recently passed a bill reducing license fees in this state. It is estimated that this reduction will amount to about $2,300,000 in basic revenues.

T. H. Cutler, Jefferson City, Mo., is chief engineer State Highway Department.

▼

South Atlantic States

Delaware

State funds available for 1934 construction total $1,000,000. In addition, $350,000 of state funds are available for maintenance. The N.R.A. funds available for 1934 construction are approximately $1,400,000.

The state highway completed in 1933 included 102.6 miles of gravel and slag surface, 16 ft. wide, 2 in. thick at an average cost of $2,500 per mile, and 22.7 miles of 20 ft. 8 in. portland cement concrete at an average cost of $40,000 per mile. In addition, 7.2 miles of roads were graded for an 80 ft. width.

The uncompleted construction carried over to 1934 included 3.6 miles of portland cement concrete at an estimated total cost of $290,000.

The probable construction for 1934 includes 30 miles of portland cement concrete requiring an estimated expenditure of $1,400,000 and 200 miles of gravel and slag road to cost about $500,000.

W. W. Mack, Dover, Del., is State Highway Engineer.

North Carolina

The state highway completed in 1933 is shown in the following tabulation:

STATE HIGHWAY COMPLETED IN 1933 IN NORTH CAROLINA

Types	Miles	Average Width Surface Ft.	Thickness, Inches	Estimated Av. Cost Per Mile
P. C. Concrete	10.81	18	6½	$21,572
Bituminous Mix	17.18	18	2½	5,312
Bituminous Surface Treatment	222.74	18	2	3,364
Gravel	103.29	18	6	5,523
Graded	125.61	..	..	4,201
Sand Asphalt	75.88	18	4	9,052
Sand Clay and Topsoil	143.74	18	7	4,732
Traffic Bound Macadam	107.16	18	6	8,984
Structures	.....	..	..	1,449

The uncompleted construction carried over to 1934 is as follows:

UNCOMPLETED CONSTRUCTION CARRIED OVER TO 1934

Types	Miles	Estimated Total Cost
P. C. Concrete	3.94	$ 110,613
Bituminous Surface Treatment	213.24	1,129,451
Gravel	12.57	107,670
Graded	9.87	49,921
Sand Asphalt	11.84	148,042
Sand Clay and Topsoil	75.33	471,295
Traffic Bound Macadam	54.79	555,827
Structures	.....	346,760

The probable new construction for 1934 will involve an estimated expenditure of $7,500,000. It includes the following:

PROBABLE CONSTRUCTION IN 1934

Types	Miles	Average Width Surface Ft.	Thickness, Inches	Estimated Av. Cost Per Mile
P. C. Concrete	20	20	7	$22,000
Bituminous Concrete	20	20	7	22,000
Bituminous Surface Treatment	350	18	1	4,000
Gravel	85	18	7	2,000
Graded	205	30	..	4,000
Sand Asphalt	40	18	4	10,000
Topsoil	105	18	7	1,500
Traffic Bound Macadam	75	18	6	6,000
Municipal Project (total) Asphalt and Concrete				2,500,000
Grade Crossing Protection and Separation (total)				600,000
Roadway Beautification				100,000

John D. Waldrop, Raleigh N. C., is State Highway Engineer.

Maryland

In 1933 Maryland had a $10,000,000 highway program, 50 per cent of which was for construction and reconstruction of approximately 120 miles of roads of various types. The 1934 program provides for approximately $18,000,000, of which 60 per cent will be for new construction and reconstruction and 40 per cent for maintenance of 3,800 miles of state and 11,000 miles of county highways and for general debt service.

H. D. Williar, Jr., Baltimore, Md., is Chief Engineer, Maryland State Roads Commission.

West Virginia

A total of 232 miles of state highway was completed in 1933, involving an expenditure of $5,516,000. The probable expenditures in 1934 are $6,500,000 and the estimated mileage is 275.

East South Central States

Alabama

State funds available for use in 1934 are approximately $500,000 for construction and $1,900,000 for maintenance. N.R.A. funds available for 1934 for construction amount to $7,345,000. State highway completed in 1933 included 136 miles of portland cement concrete, 29 miles bituminous concrete, 38 miles of bituminous mix and bridges costing $478,492. Data on the 1933 work follow:

STATE HIGHWAY COMPLETED IN 1933 IN ALABAMA

Types	Miles	Average Width Surface Ft.	Thickness, Inches	Estimated Av. Cost Per Mile
P. C. Concrete	136.6	20	9–6–9	$22,470
Bituminous Concrete	29.3	20	5	21,430
Bituminous Macadam	0.0	..	..	.....
Bituminous Mix	37.8	20	2½	11,290
Bituminous Surface Treatment	1.6	20	..	26,500
Gravel	0.0	..	..	.....
Graded	46.3	..	..	9,850

The uncompleted work carried over to 1934 is estimated to cost $4,180,000 and includes the following:

UNCOMPLETED CONSTRUCTION CARRIED OVER TO 1934

Types	Miles	Estimated Total Cost
P. C. Concrete	60.1	$1,500,000
Bituminous Concrete	32.7	800,000
Bituminous Macadam	0.0	.....
Bituminous Mix	92.0	1,380,000
Bituminous Surface Treatment	33.0	330,000
Gravel	6.0	.....
Graded	16.7	170,000

The probable new construction for 1934 will require an estimated expenditure of $7,345,000, involving the following:

PROBABLE CONSTRUCTION IN 1934

Types	Miles	Estimated Total Cost
P. C. Concrete	52.4	$1,700,000
Brick	0.5	15,000
Bituminous Concrete	2.1	50,000
Bituminous Macadam	0.0	.....
Bituminous Mix	96.2	1,700,000
Bituminous Surface Treatment	217.3	2,500,000
Gravel	124.0	90,000
Graded	58.7	880,000
Bridges	....	300,000
Miscellaneous	....	110,000

L. G. Smith, Montgomery, Ala., is State Highway Commissioner.

Kentucky

The expenditures of the State Highway Department for 1933 were $18,666,000. It is not possible at this time to estimate the expenditures for 1934 until the General Assembly now in session has made funds available.

West South Central States

Texas

The State Highway Department had 2,042 miles of highway under construction on Nov. 30, the types and cost being as follows:

PROJECTS UNDER CONSTRUCTION ON NOV. 30, 1933.

Type	Mileage	Cost
Grading and Small Structures	1,027.40	$ 8,913,745
Gravel Surface	37.12	188,510
Caliche or Disintegrated Limestone	75.32	476,286
Shell Surface	14.10	244,358
Macadam Surface (including Crushed Rock or Stone)	21.15	115,537
Single Bituminous Treatment on Caliche or Disintegrated Limestone	191.43	290,953
Single Bituminous Treatment on Iron Ore Soil	92.69	659,455
Single Bituminous Treatment on Gravel	107.60	155,639
Single Bituminous Treatment on Macadam	78.19	163,953
Double or Triple Bituminous Treatment on Caliche or Disintegrated Limestone	110.34	740,397
Double or Triple Bituminous Treatment on Iron Ore Soil	7.18	75,578
Double or Triple Bituminous Treatment on Macadam	13.84	41,875
Limestone Rock Asphalt on Gravel	42.84	354,097
Two Course Rock Asphalt on Gravel	.67	34,014
Two Course Rock Asphalt on Macadam	.68	13,769
Asphalt Macadam on Macadam	34.11	282,200
Asphaltic Concrete on Macadam	3.26	100,569
Asphaltic Concrete on Concrete	19.16	618,335
Concrete Pavement—Reinforced	164.85	3,272,313
Brick on Concrete	.33	21,213
Total Highways	2,042.26	$16,762,803
Bridges—Concrete		382,247
Bridges—Concrete and Steel		920,160
Bridges—Steel and Timber		6,859
Bridges—Steel, Concrete and Timber		164,035
Underpasses—Concrete and Steel		118,864
Overpasses—Concrete and Steel		233,251
Total Structures		$ 1,825,419
Grand Total		$18,588,223

Note: Cost based on estimated quantities at contract price.

The construction contracts let from September, 1932, through August, total 1,428 miles at a total cost of $17,040,310. Details follow:

SUMMARY OF CONSTRUCTION CONTRACTS LET BY STATE HIGHWAY DEPARTMENT FROM SEPTEMBER, 1932, THROUGH AUGUST, 1933.

Type	Mileage	Amount
Grading and Small Structures	639.96	$ 5,865,124
Gravel Surface	15.09	84,906
Caliche or Disintegrated Limestone	85.57	538,292
Macadam Surface (including Crushed Rock or Stone)	55.16	413,039
Iron Ore Soil Surface	31.17	190,025
Single Bituminous Treatment on Caliche or Disintegrated Limestone	77.71	427,928
Single Bituminous Treatment on Gravel	12.64	101,840
Double or Triple Bituminous Treatment on Caliche or Disintegrated Limestone	18.74	164,604
Double or Triple Bituminous Treatment on Macadam	34.66	359,569
Limestone Rock Asphalt on Gravel	13.23	138,618
Limestone Rock Asphalt on Macadam	18.63	212,874
Two Course Rock Asphalt on Concrete	5.31	20,561
Asphalt Macadam on Macadam	21.61	168,119
Asphaltic Concrete on Concrete	11.25	275,190
Concrete Pavement—Reinforced	384.06	7,948,619
Brick on Concrete	3.21	129,996
Total Highways	1,428.00	$17,040,309
Bridges—Concrete		199,985
Bridges—Concrete and Steel		383,128
Bridges—Steel, Concrete and Timber		322,737
Underpasses—Concrete and Steel		243,277
Overpasses—Concrete and Steel		123,993
Total Structures		$ 1,273,122

The construction projects completed from Sept. 1, 1932, to Aug. 31, 1933, aggregated 2,609 miles, the cost being $25,037,431. The mileages and costs of the various types were as follows:

CONSTRUCTION PROJECTS COMPLETED SEPT. 1, 1932, TO AUG. 31, 1933.

Type	Mileage	Cost
Grading and Small Structures	936.40	$ 5,887,368
Gravel Surface	38.55	192,985
Caliche or Disintegrated Limestone	222.09	1,148,468
Macadam Surface (including Crushed Rock or Stone)	181.86	1,226,292
Iron Ore Soil Surface	42.12	266,140
Single Bituminous Treatment on Caliche or Disintegrated Limestone	83.00	571,972
Single Bituminous Treatment on Iron Ore Soil	9.27	36,181
Single Bituminous Treatment on Gravel	24.75	231,140
Double or Triple Bituminous Treatment on Caliche or Disintegrated Limestone	160.60	936,738
Double or Triple Bituminous Treatment on Iron Ore Soil	15.77	119,289
Double or Triple Bituminous Treatment on Gravel	28.97	177,178
Double or Triple Bituminous Treatment on Macadam	69.67	557,523
Limestone Rock Asphalt on Macadam	18.63	203,026
Two Course Rock Asphalt on Macadam	15.64	23,731
Two Course Rock Asphalt on Concrete	5.30	20,585
Asphalt Macadam on Macadam	8.12	40,893
Asphaltic Concrete on Concrete	11.25	281,805
Concrete Pavement—Reinforced	733.44	12,964,754
Brick on Macadam with Concrete Shoulders	.28	18,161
Brick on Concrete	3.21	133,193
Total Highways	2,608.92	$25,037,431
Bridges—Concrete		379,761
Bridges—Concrete and Timber		109,112
Bridges—Concrete and Steel		1,374,877
Bridges—Steel and Timber		502,435
Underpasses—Concrete and Steel		214,718
Overpasses—Concrete and Steel		85,476
Total Structures		$ 2,738,590

Gibb Gilchrist, Austin, Tex., is State Highway Engineer.

Mountain States

Wyoming

The State Highway Department has $200,000 of state funds available for construction in 1934 and $900,000 for maintenance. In addition there will be $900,000 of N.R.A. funds available. The state highway completed in 1933 comprised 75 miles of bituminous mix and bituminous surface treatment, 230 miles of gravel and 65 miles of graded road, details of which follow:

STATE HIGHWAY COMPLETED IN 1933 IN WYOMING

Types	Miles	Average Width Surface Ft.	Thickness, Inches	Estimated Av. Cost Per Mile
Bituminous Mix and Bituminous Surface Treatment	75	24	..	$ 5,000
Gravel	230	24	6	2,550
Graded	65	24	..	5,000

The incompleted construction carried over to 1934 includes 300 miles of bituminous mix and bituminous surface treatment estimated to cost $1,500,000; 120 miles of gravel road, to cost $300,000 and 100 miles of graded road to cost $500,000.

The probable construction for 1934 includes 100 miles of bituminous mix and bituminous surface treatment estimated to cost $500,000 and 75 miles of gravel and graded roads estimated to cost $400,000.

Jas. B. True, Cheyenne, Wyo., is State Highway Engineer.

Utah

The State Highway Department has $1,000,000 of state funds available for construction in 1934 and $1,200,000 for maintenance. Nearly all of the N.R.A. funds have already been obligated.

The state highway work completed in 1933 included 38 miles portland cement concrete, 42 miles bituminous mix and bridges of a total cost of $375,127. Details of the 1933 work follow:

STATE HIGHWAY COMPLETED IN 1933 IN UTAH

Types	Miles	Average Width Surface Ft.	Thickness, Inches	Estimated Av. Cost Per Mile
P. C. Concrete	38.1	20	7	$30,000
Asphalt	4.5	20	1½	10,000

Bituminous Mix (Plant Mix)	42.5	18	3	7,000
Bituminous Surface Treatment	114.1	18	3	2,500
Gravel and Grading	150.6	18	6	7,500

The incompleted work carried over to 1934 included the following:

UNCOMPLETED CONSTRUCTION CARRIED OVER TO 1934

Types	Miles	Estimated Total Cost
P. C. Concrete	19.2	$580,978
Asphalt	8.3	85,286
Bituminous Mix (Plant Mix)	29.1	192,677
Bituminous Surface Treatment	4.6	15,000
Gravel	124.4	583,274
Graded	34.3	58,000
Bridges	....	162,727

The construction program for 1934 is not available at this time.

H. S. Kerr, Salt Lake City, Utah, is State Highway Engineer.

New Mexico

State highway completed in 1933 included 163 miles of road mix oil surface, 71 miles of graded road, and 199 miles of grading, drainage and base work. Details are shown in the table:

STATE HIGHWAY COMPLETED IN 1933 IN NEW MEXICO

Types	Miles	Average Width Surface Ft.	Thickness, Inches	Estimated Av. Cost Per Mile
P. C. Concrete	8.6	20	6	$25,000
*Brick, Gd. Dr. & Concrete	1.4	20	6	35,000
Road Mix, Oil Surf.	163.0	20	2½	5,400
Graded	71.0	26 & 28	..	10,300
Gd. Dr. & Base	199.0	22	5	11,700
Penet. Type Oil	31.2	20	..	4,000
Base Surf. (all kinds)	63.0	22	5	3,700

*Includes grading, drainage and foundation concrete.

The incompleted construction carried over to 1934 includes the following:

UNCOMPLETED CONSTRUCTION CARRIED OVER TO 1934

Types	Miles	Estimated Total Cost
P. C. Concrete	2.0	$ 85,000
Oil Treated Gravel	121.3	921,000
Graded	9.8	94,000
Grade, Dr. & Base	29.6	520,000
Bridges	....	268,000

The probable construction for 1934 includes the following:

PROBABLE CONSTRUCTION IN 1934

Types	Miles	Estimated Total Cost
P. C. Concrete	0.3	$35,000
Graded	45.6	382,000
*NRWR Grad. & Partly Surf.	475.0	800,000
*NRJ Grad., Dr. & Surf.	516.0	1,000,000
Gd., Dr., Base, Surf. & Oil 10 Munic. Jobs	15.0	216,000
Oil Surface	174.0	715,000
Widen Paving, 10 Munic. Jobs	7.8	189,000
Bridges & RR Separations	....	528,000

*None of this mileage was completed in 1933. All carry over to 1934 (started Nov. & Dec., 1933).

G. D. Macy, Santa Fe, N. Mex., is State Highway Engineer.

Nevada

State highway completed in 1933 included 249 miles of bituminous mix and 183 miles of gravel road. The type and costs were as follows:

STATE HIGHWAY COMPLETED IN 1933 IN NEVADA

Types	Miles	Average Width Surface Ft.	Thickness, Inches	Estimated Av. Cost Per Mile
P. C. Concrete	6.34	20–40	9–7–9	$301,300
Bituminous Concrete	5.46	20	3–9	117,100
Bituminous Mix	249.13*	20	3	893,900
Gravel	182.78	20	6	1,260,600

*70.99 miles oiled and cost included under bituminous mix.

The uncompleted construction carried over to 1934 included 25.4 miles bituminous mix, estimated to cost $510,800, this including grading and base; also 204.5 miles of gravel road to cost $1,443,300.

Construction program for 1934 has not been completed. It will total about $2,500,000.

S. C. Durkee, Carson City, Nev., is State Highway Engineer.

Colorado

The state highway completed in 1933 amounted to 386 miles and included 215 miles of gravel road, 97 miles of bituminous surface treatment and 29 miles of concrete. Details follow:

STATE HIGHWAY COMPLETED IN 1933 IN COLORADO

Types	Miles	Average Width Surface Ft.	Thickness, Inches	Estimated Av. Cost Per Mile
P. C. Concrete	29	20	7	$34,000
Bituminous Concrete	2	30	7	47,000
Bituminous Mix	38	22	2½	5,500
Bituminous Surface Treatment	97	22	1	1,000
Gravel	215	22	4	15,000
Graded	5	30	..	13,000

It is not possible at this time to give definite figures on the 1934 program. However, the budget submitted to the Governor calls for an expenditure of $3,650,000, divided as follows:

State projects on Federal Aid system	$1,789,000
Maintenance	1,600,000
Surveys	50,000
Traffic signs and census	20,000
Property and equipment	20,000
Compensation insurance	25,000
Administration	146,000
Total	$3,650,000

This budget has not at this writing been approved by the Governor. The legislature also is in special session and has not determined on funds for the coming year.

Pacific Coast States

Washington

The work completed during 1933 is approximately as follows:

	Miles
Grading only	42
Grading and Surfacing	99
Surfacing only	33
Asphaltic Macadam	67
Cement Concrete	13

The cost will be approximately $5,000,000.

It is expected that all of the state's $6,155,000 allotment of National Recovery funds will be obligated and placed under contract by about the first week in January. Of this fund it is estimated that about $800,000 will have been earned on contracts before Jan. 1st, leaving about $5,355,000 in uncompleted National Recovery projects to be carried over into 1934. In addition to the above, the State Highway Department expects to have available for highway construction about $5,600,000 of state and bond issue funds and about $1,500,000 of Federal Grant funds during the coming year.

L. V. Morrow, Olympia, Wash., is State Highway Director.

Oregon

State funds available for use in 1934 include $200,000 for construction and $2,870,000 for maintenance. In addition there are $6,000,000 of N.R.A. funds available for construction in 1934.

The state highway completed in 1933 included the following:

STATE HIGHWAY COMPLETED IN 1933 IN OREGON

Types	Miles	Average Width Surface Ft.	Thickness, Inches	Estimated Av. Cost Per Mile
P. C. Concrete	23	20	7–9	$30,000
Bituminous Concrete	18	20	5	15,000
Bituminous Macadam	66	20	3	10,000
Bituminous Surface Treatment	27	20	1½	5,000
Gravel and Crushed Rock Surface	86	20	10	5,000
Graded	142	..	..	.....

The incompleted construction carried over to 1934 is as follows:

UNCOMPLETED CONSTRUCTION CARRIED OVER TO 1934

Types	Miles	Estimated Total Cost
P. C. Concrete	17	.....
Brick	..	.....
Bituminous Concrete	21	.....
Bituminous Macadam	98	.....
Bituminous Mix	..	.....
Bituminous Surface Treatment	43	.....
Gravel & Crushed Rock Surface	73	.....
Graded	91	.....

The probable additional contracts to be let in 1934 include:

PROBABLE ADDITIONAL CONTRACTS TO BE LET IN 1934

Types	Miles	Estimated Total Cost
P. C. Concrete	8	.....
Bituminous Concrete	4	.....

Bituminous Macadam	4	.....
Bituminous Surface Treatment	22	.....
Gravel and Rock Surface	21	.....
Graded	18	.....

R. H. Baldock, Salem, Ore., is State Highway Engineer.

California

During 1933 there were carried to completion 142 miles of portland cement concrete pavement, 60 miles of bituminous concrete pavement, 131 miles of bituminous or oil treated crushed gravel or stone surfacing, 2 miles of gravel surfacing and 62 miles of grading.

Work under construction carried over to 1934 consists of 51 miles of portland cement concrete, 75 miles of bituminous concrete, 362 miles of bituminous treated or oil treated crushed gravel or stone, 21 miles of gravel surfacing and 125 miles of graded roadway.

During 1934 it is proposed to place under way approximately 105 miles of portland cement concrete and bituminous concrete pavement, 100 miles of bituminous treated or crushed gravel or stone surfacing, 42 miles of gravel or stone surfacing and 38 miles of grading.

Funds for the Division of Highways are based on the biennial period. For this biennium the period covered is from July 1, 1933, to June 30, 1935. Anticipated revenue for this period amounts to approximately $54,136,000 from gas tax, motor vehicle fees and highway transportation companies, and $15,607,354 from National Recovery Highway Funds.

C. H. Purcell, Sacramento, Calif., is State Highway Engineer.

PROBABLE COUNTY ROAD EXPENDITURE FOR 1933 AND 1934 FOR 150 COUNTIES

State and County	Construction 1933	Construction 1934	Maintenance 1933	Maintenance 1934
ARIZONA:				
Gila	.....	$900,000[1]	$70,000	$70,000
Pinal	.....	.....	80,000	80,000
CALIFORNIA:				
Fresno	.....	.....	400,000	400,000
Kings	$74,000	26,000	174,000	165,000
Lassen	28,565	50,000	71,202	60,000
San Joaquin	59,094	57,650	453,800	467,566
COLORADO:				
Denver[2]	.....	.....	120,000[3]	20,000[3]
Elbert	50,000	40,000	36,000	30,000
La Plata	30,000	20,000	50,000	40,000
FLORIDA:				
Broward	15,000	35,000	30,000	30,000
De Soto	.....	.....	12,500	12,500[4]
Lee	10,000	140,000	20,000	25,000
IDAHO:				
Twin Falls	11,500	10,000	28,000	30,000
ILLINOIS:				
Calhoun	5,000	9,000	7,000	6,000
Carroll	20,000	30,000	10,000	10,000
Coles	45,000	50,000	.....	.....
Cook	2,750,000	3,500,000	50,000	75,000
Edgar	11,000	3,000	9,000	7,000
Jackson	.....	20,000	5,500	6,000
Jefferson	20,000	15,000	15,000	15,000
Kane	115,000	160,000	35,000	40,000
Lake	270,000	175,000	50,000	65,000
Menard	20,000	30,000	11,000	6,000
Peoria	100,000	300,000	40,000	80,000
Stark	25,000	30,000	5,000	8,000
Vermilion	18,000	120,000	13,200	8,300
Wayne	30,000	30,000	3,000	3,500
Winnebago	237,000	295,000	20,000	20,000
INDIANA:				
Allen	45,000	45,000	65,000	65,000
Clinton	15,000	20,000	60,000	60,000
Grant	.....	5,000	1,500	3,000
Jefferson	20,000	60,000	33,000	.....
Koscuisko	80,000	50,000	70,000	90,000
Noble	50,000	50,000	25,000	25,000
Orange	.....	.....	51,000	70,000
Ripley	25,000	15,000	67,794	60,000
Tippecanoe	.....	.....	160,000	110,000
Warrick	20,000	23,000	60,000	60,000
Wayne	.....	.....	98,525	100,000
IOWA:				
Cass	19,000	12,000	80,000	70,000
Decatur	40,000	45,000	60,000	55,000
Dickinson	18,000	12,000	20,000	14,000
Dubuque	100,000	90,000	85,000	70,000
Guthrie	75,000	200,000[5]	95,000	60,000
Harden	55,000	35,000	70,000	75,000
Iowa	22,644	35,000	69,462	60,000
Jasper	125,000	80,000	112,000	100,000
Lyon	5,500	5,500	82,000	82,000
Marion	60,000	50,000	67,000	50,000
Osceola	23,000	23,000	59,252	58,200
Page	40,000	30,000	88,000	90,000
Palo Alto	65,000	50,000	75,000	50,000
Union	33,776	130,500	76,128	52,100
Wayne	37,000	35,000	73,000	56,000
KANSAS:				
Cherokee	37,619	45,000	58,722	60,000
Greenwood	57,000	48,000	20,000	10,000
Hamilton	6,328	8,000	4,437	5,000
Marshall	71,000	75,000	25,000	25,000
Miami	134,000[5]	40,000	.....	80,000
Osborne	29,523	31,000	5,181	6,000
KENTUCKY:				
Boyd	.....	.....	24,250	20,000
Madison	48,000	40,000	40,000	35,000
Nelson	30,000	20,000	20,000	15,000
Simpson	14,000	12,000	6,000	6,000
LOUISIANA:				
Caddo[6]	250,000	55,000[7]	.....	.....
Morehouse[6]	5,000	10,000	45,000	45,000
MASSACHUSETTS:				
Essex	80,000	80,000	.....	.....
Plymouth	69,100	100,000	.....	.....
MICHIGAN:				
Barry	35,000	35,000	40,000	45,000
Branch	.....	30,000	120,000	125,000
Genesee	443,975	240,000	169,148	225,000
Ingham	73,774	125,000	220,344	250,000
Ionia	.....	.....	26,161	49,000
Iosco	5,000	10,000	14,000	14,000
Keweenaw	211,000	240,000	40,000	40,000
Luce	24,000	18,000	31,000	24,000
Muskegon	50,000	.....	100,000	100,000
Van Buren	.....	.....	117,774	87,774
MINNESOTA:				
Benton	50,000	40,000	10,000	10,000
Carlton	10,000	20,000	30,000	30,000
Chisago	43,462	25,000	29,690	24,000
Cottonwood	28,000	25,000	30,000	28,000
Lake	87,056	95,000	28,091	25,000
Marshall	5,000	70,000	35,000	35,000
Olmsted	58,500	40,000	60,000	60,000
Steele	40,000	40,000	25,000	25,000
Wright	70,000	105,000	30,000	30,000
MISSOURI:				
Daviess	6,000	6,000	6,000	6,000
Howard	13,000	.....	.....	.....
Moniteau	13,040	10,000	.....	.....
Monroe	10,000	9,000	15,000	12,000
St. Louis	1,228,391	400,000	510,000	500,000
MONTANA:				
Blaine	4,500	7,200	8,642	10,860
Cascade	50,000	40,000	61,432	50,000
Petroleum	.....	3,000	14,000	10,000
Ravalli	10,000	10,000	30,000	25,000
Silver Bow	18,000	.....	57,000	.....
Wheatland	18,000	25,000	5,000	7,500
NEBRASKA:				
Brown	.....	.....	11,700	13,000
Richardson	40,000	40,000	65,000	65,000
NEVADA:				
Lincoln	17,149	.....	8,574	.....
NEW JERSEY:				
Morris	70,000	70,000	270,000	280,000
NEW YORK:				
Clinton	41,565	87,852	69,750	52,848
Ontario	75,000	.....	45,000	45,000
St. Lawrence	350,000	350,000	34,000	34,000
Saratoga	135,000	135,000	82,000	82,000
Tompkins	135,000	125,000	35,000	45,000
NORTH DAKOTA:				
Kidder	3,700	4,000	4,200	3,500
McLean	2,000	2,000	8,000	6,000
Sheridan	19,500	35,000	6,400	7,000
Ward	6,000	15,000	8,000	15,000
OHIO:				
Athens	60,000	75,000	125,000	70,000
Daske	.....	.....	80,000	60,000

Geauga	.....	.....	57,000	60,000
Harrison	28,000	30,000	57,000	60,000
Hocking	270,611	250,000	110,000	100,000
Knox	30,000	10,000	90,000	95,000
Lake	14,000	12,000	54,000	45,000
Lucas	.....	.....	105,000	150,000
Mercer	25,000	20,000	30,000	35,000
Montgomery	5,000	20,000	135,000	120,000
Morgan	35,000	25,000	45,000	45,000
Richland	29,000	4,000	72,000	50,000
Wayne	100,000	.....	65,000	45,000
OREGON:				
Baker	5,000	10,000	10,000	10,000
Benton	38,000	35,000	30,000	30,000
Jackson	30,000	25,000	40,000	50,000
Polk	.....	.....	51,769	89,874
Yamhill	15,000	12,000	22,000	20,000
SOUTH DAKOTA:				
Douglas	12,000	5,000	10,000	15,000
Jerauld	.....	5,000	3,000	.....
Jones	.....	20,000	.....	5,000
TENNESSEE:				
Gibson	.....	30,000	50,000	50,000
Humphreys	10,000	10,000	25,000	25,000
Obian	.....	.....	75,000	75,000
Pickett	20,000	20,000	5,000	5,000
TEXAS:				
Cameron	.....	10,000	100,000	100,000
Colorado	10,000	50,000	25,000	30,000
Dewitt	150,000	150,000	20,000	.....
Madison	.....	20,000	20,000	20,000
WASHINGTON:				
Ferry	37,000	35,000	10,000	12,000
Skamania	50,000	55,000	40,000	40,000
Spokane	116,788	88,245	78,253	134,000
Walla Walla	55,770	110,000	100,000	169,000
Whitman	130,000	90,000	130,000	170,000
WISCONSIN:				
Bayfield	27,327	20,000	6,396	7,000
Milwaukee	50,000	450,000	300,000	300,000
UTAH:				
Sevier	3,000	3,000	2,000	2,000
WYOMING:				
Big Horn	.....	.....	20,000	20,000
Natrona	20,000	10,000	42,000	38,000
Sweetwater	40,000	40,000	25,000	25,000

[1]C.W.A. work. [2]City and County of Denver. [3]Street oiling and maintenance. [4]$10,000 to $15,000. [5]P.W.A. [6]Parish. [7]Plus $500,000 P.W.A. funds if approved; plus $90,000 C.W.A. if approved. [8]Construction and maintenance. [9]Twin Falls Highway District.

Tests on a Reinforced Concrete Arch

The United States Bureau of Standards cooperated with the Arlington Memorial Bridge Commission in an investigation of the structural behavior of one of the reinforced-concrete arch spans of the Arlington Memorial Bridge at Washington, D. C. Data were obtained on the changes in temperature of the concrete, the coefficient of thermal expansion of the arch, the deflections and deformations of the arch, and the movements of the piers and of the expansion joints.

Temperatures in the concrete were determined with thermocouples and resistance thermometers. The rotations and deflections of the arch barrel were measured by means of clinometers on a continuous line of stations extending over the extrados of the arch and a portion of both piers. Deformations of the extrados and the intrados of the arch were measured respectively with strain gages and electric telemeters.

Some of the results obtained are outlined in the November Technical News Bulletin as follows:

1. The generation of heat incident to the hardening of the concrete raised the temperature of the thicker portions of the arch barrel to a maximum of more than 140° F. within a period of 25 hours after pouring.

2. The maximum and minimum average temperatures of the arch barrel resulting from seasonal changes in temperature were respectively 85° F. and 24° F.

3. The coefficient of thermal expansion of the arch barrel was found to be approximately 0.0000065 per ° F.

4. The deflections of the crown caused by changes of temperature were about 13 per cent less after construction of the superstructure than before.

5. Shrinkage and flow during a period of 2 years following the construction of the arch barrel had approximately the same effect on the deflection of the arch as a drop of 27° F. in the temperature of the concrete.

The complete report of this work is published as Research Paper No. 609 in the November number of the Bureau of Standards Journal of Research.

State Associations Affiliate with A. R. B. A.

The Massachusetts Highway Association and the Connecticut Road Builders' Association have affiliated with the American Road Builders Association. The New England Road Builders' Association also has taken similar action. The latter is one of the oldest highway contractors association in the country and has been actively engaged in bettering the conditions in highway contracting. The Association's headquarters are in Boston and its large membership extends throughout the New England states. The New England Road Builders' Association has taken an active leadership in legislation and the formation of policies affecting highway contractors. Charles Knowlton, President of the association, has served the highway industry as an engineer, official and contractor for many years and its secretary, Frederick Hoitt who has been connected with the Association many years, has contributed much to the benefit of highway contractors.

The membership of the Connecticut organization of which Louis E. Guyott of New Haven, is president, includes every outstanding highway contractor resident in the state of Connecticut. Mr. Guyott has taken an active part in discussion of a highway contractors code and is chairman of the special executive committee appointed at the Highway Contractors Code meeting held in Washington, Oct. 31 and Nov. 1.

The Massachusetts Highway Association was organized in 1893 and is one of the oldest and most active highway associations. It has long been a leader in shaping the highway policy of the state and its membership is made up of outstanding engineers and officials of state, cities, counties and towns. It has a large associate membership, comprising, the outstanding firms and individuals connected with the highway program. Its president, Franklin C. Pillsbury is project engineer of the Massachusetts Department of Public Works. John McCarthy has been secretary of the Association since its beginning and during this time has held high positions with the Department of Public Works.

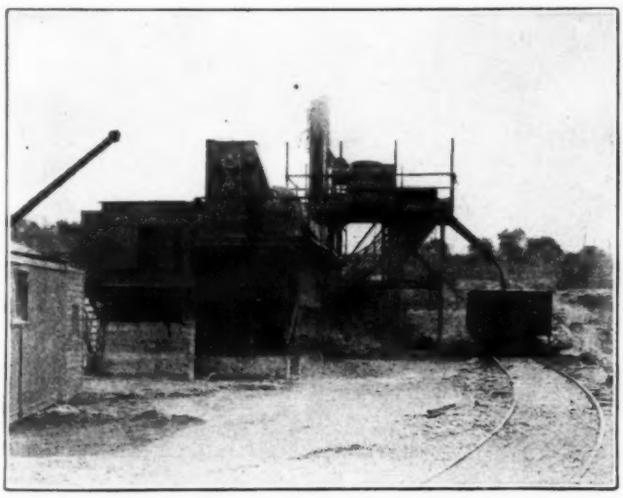
Important Link in Pan-American System to Be Opened Next Autumn

The Mexican government is increasing its forces in building the great highway which will connect Mexico City with the highway system of the United States so that the road across the Rio Grande and the mountains to the capital of the southern republic may be opened next Autumn.

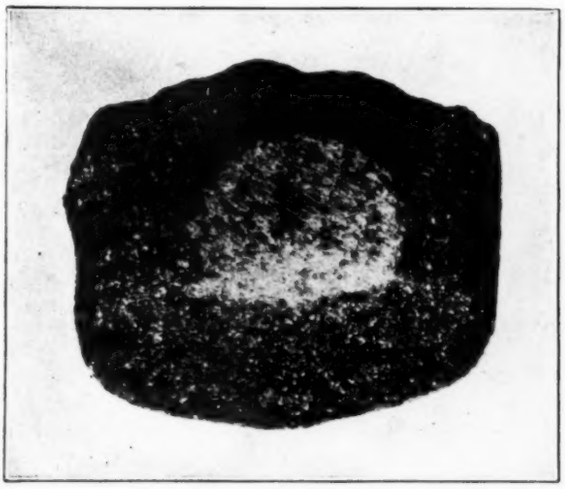
Cold-Lay Asphalt Paving Mixture Has Waterproofed Aggregate

A RESURFACING job carried out last fall on Route 6 near Dixon, Ill., had several unusually interesting features. Chief of these was a specially designed continuous asphalt mixing plant and a process both of which contained many unique features. The work called for the resurfacing of two miles of old brick paved highway. The new surface was 18 ft. wide and 2 in. thick, the material employed being Sealdrok, a new cold-lay asphalt paving mixture. The mixture was shipped from the Sealdrok plant at Joliet, Ill., in open top gondola cars. The haul to Dixon, Ill., was 100 miles. The material was unloaded by the contractor with a clamshell and hauled 2 miles to the job in trucks, where it was spread on the road and rolled. The total cost of this hauling, unloading, spreading and rolling was 18 ct. per square yard. No skilled labor was required, the work being done by local men. The contractor was the Chicago Construction Co., 228 North La Salle St., Chicago, Ill. The work was done under the supervision of the Illinois State Highway Department.

One of the outstanding features of the Sealdrok paving mixture used in this job is the waterproofing of the aggregate. This is accomplished by treating the aggregate with an asphaltic base waterproofing compound which penetrates readily and leaves a thin film of asphalt around each particle. This, it is claimed, not only protects the aggregate from future absorption of moisture but forms a bond to which the asphalt cement—which in this case was Texaco, 60-70 penetration—is subsequently applied and which readily adheres to the waterproofed aggregate. All aggregate used in the process is thoroughly dried before it is waterproofed, giving a product which contains no moisture and which will not absorb moisture, lessening, to a minimum, the destructive action caused by freezing and thawing.



A View of the Compact Sealdrok Mixing Plant at Joliet, Ill.



A ¾-in. Piece of Aggregate Showing Penetration of Waterproofing Compound.

The asphalt mixing plant also is of particular interest. Among its distinguishing features are:

Materials are passed through a chamber where they are first dried and then cooled, eliminating the danger of any injurious effect on the asphalt due to over-heating.

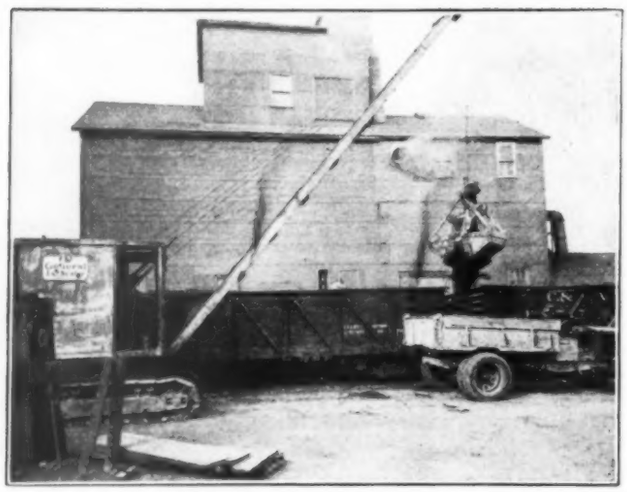
The aggregate is then passed over a screen which separates it into three or four sizes, as desired, and deposits each size in a separate bin.

From the waterproofing mixer the mixture passes into

Laying the Material on Road. Notice That Material Can Be Dumped a Considerable Distance Ahead of Rakers, Making It Unnecessary to Hold Any Trucks on Job.

An eccentric feed delivers, with great accuracy, the portion of each size specified or desired. Each size aggregate is distributed evenly and uniformly in layers on a conveyor and is elevated to the waterproofing mixer.

The waterproofing compound is added at a uniform rate, which is accurately controlled, and the aggregate is thoroughly treated with the waterproofing compound.



Demonstrating the Ease of Handling Materials Which Have Been Both Waterproofed and Mixed with Asphalt Cement, and Which Have Stood in Open Gondola Cars for Eight Days.

the mixer where the asphalt cement is added. The mixing requires three minutes. All aggregate receives the same amount of waterproofing compound, asphalt cement, and mixing. These features, combined with the positive delivery of the desired quantity of each size of aggregate are claimed to produce a mixture of exceptional uniformity.

Another feature of the plant is its simplicity and ease of operation. It is automatically controlled, and three men are all that are required to operate it.

The Sealdrok mixture can be handled by trucks, or it may be loaded in cars and shipped any practical distance and it is still easily handled at its destination, and if desired it may be stock-piled. The time required for setting can be controlled in the mixing. The material can be raked or spread with a mechanical spreader, allowed to stand a short time, and then rolled. It is immediately ready for traffic.

The Sealdrok process further provides that the mineral aggregate after being thoroughly dried and properly graded to meet specific specifications, and impregnated with the waterproofing compound, may be shipped as such and stock piled for future use. The asphalt coating may be applied with the most inexpensive kind of equipment, such as a concrete mixer, by hand, or by the penetration method.

The Sealdrok process also covers the treatment of stone dust and screenings, which are now more or less a waste product at quarries. This treated material may be stored in convenient stock piles for future use and may be utilized for covering all macadam roadways and streets; for covering of park areas to prevent dust; under sidewalks in place of cinders, and many other uses. Sand may be treated and used for the same purposes.

This process and equipment were developed by the American Sealdrok Corporation, 43 East Ohio St., Chicago, Ill.

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Highway Department Provides Wood for Needy

More than 1,000 cords of seasoned firewood is being supplied to relief organizations by the State Highway Department, according to a report to Commissioner N. W. Elsberg by the department's roadside development division. This wood largely comes from parts of the state where modern highways parallel railroad rights of way and old snow fences and cattle fences are no longer needed.

Wood obtained from the fences is distributed through relief agencies in the towns nearest the improvement. Permission has been granted by the Great Northern railroad to remove fences from Albany, in Stearns county, to Evansville, in Douglas county. Other projects under way or completed are on Trunk Highway No. 20, from Harmony to the Iowa line; on highways between Anoka and Brainerd; on Trunk Highway No. 1 from St. Paul to Duluth, and smaller stretches in other parts of the state.

The department is beautifying the highways by clearing all old fences and posts between state and railroad rights of way where possible and is donating the wood to civic organizations to assist in their relief efforts. In some cases highway trucks are delivering the wood to central points when not otherwise laden but in most instances the relief agencies are doing their own trucking. The wood is well seasoned and makes excellent firewood.

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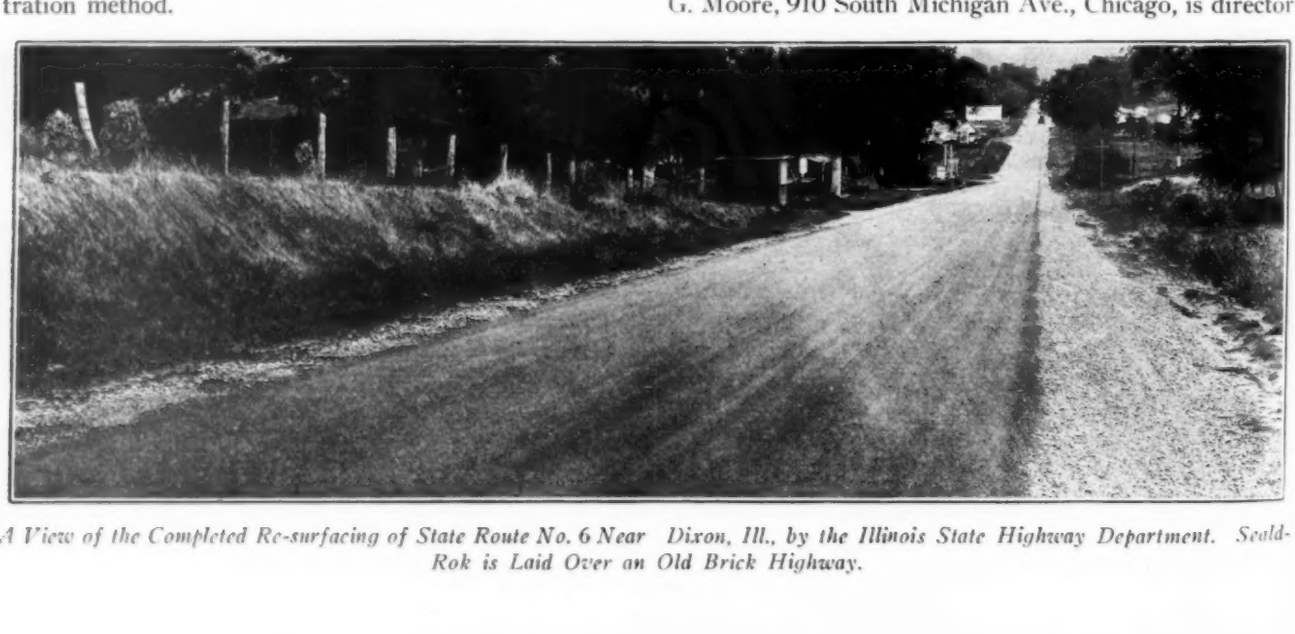
ILLINOIS HIGHWAY USERS CONFERENCE TO MEET IN CHICAGO.—The annual meeting of the Illinois Highway Users Conference will be held at 10 a. m., Jan. 15, in the west ballroom of the Stevens Hotel, Chicago. Chester G. Moore, 910 South Michigan Ave., Chicago, is director.



A View of the Completed Re-surfacing of State Route No. 6 Near Dixon, Ill., by the Illinois State Highway Department. Seald-Rok is Laid Over an Old Brick Highway.

Rational Planning of a Public Highway Program

By FRANK T. SHEETS

Former Chief Highway Engineer, Illinois

RATIONAL planning is the salvation of the highway industry. Lack of it spells ruin. The alarming invasion of road funds evidenced in recent years, climaxed by the diversion of hundreds of millions of highway dollars to uses utterly foreign, and accompanied by the crippling of state highway departments and grave cessation of construction activity, can only be stopped by arousing public opinion to the fighting pitch of positive action.

As an aid to arousing public opinion, we must develop rational plans for the highway programs in the states, embracing equitable distribution of highway revenues and adequate treatment of all classes of thoroughfares—both rural and urban, and then we must sell the plans to the public. This accomplishment will so popularize the highway movement, that highway funds will be cheerfully raised, and an alert citizenship will safeguard them for their intended use.

The day of highway hysteria is over. The bubbling good roads booster, with his sentimental appeal, must be replaced by the highway economist armed with sound plans, fundamental facts regarding the dividend producing aspects of improved highways and convincing proof of the equity of proposed highway tax collection and distribution.

Inevitably the burden of leadership in this important work falls upon the state highway official. He can command the knowledge and facilities for sound highway planning based upon traffic studies, economic surveys and kindred data; he commands the attention of the individual citizen and organized civic groups; and he, more than any one else, can educate representative citizens and civic groups so that they in turn may sell the highway program to the public at large. Failure to measure up to this responsibility is unthinkable.

As we approach rational highway planning in its broadest sense, we must stifle individual prejudices, we must discard preconceived notions and we must find out the basic facts which govern highway planning and the distribution of highway revenues. We must resolve to go where the facts lead us, because only in this way can we reach logical conclusions. Any plan which fully harmonizes with basic facts will be both rational and popular; one which ignores them will be a travesty on justice and will be sharply rebuked by public opinion.

Traffic Surveys as a Guide.—A state-wide traffic survey is almost indispensable as a guide to rational highway planning. It should develop complete information regarding the volume, character and distribution of traffic on city streets, primary or state, secondary or county trunk and tertiary or township highways.

By the term traffic survey we do not mean the extremely costly, complicated and to a certain extent aimless efforts which characterized the early transport surveys, but rather the modern version which embodies all necessary features and findings of the early surveys, but which has direct purposes in mind, employs short cuts to results and which costs relatively little. By the use of established principles for traffic station selection, short counts, and traffic approximations, costs can be reduced to a minimum.

The technical direction of the survey may be vested in a trained traffic engineer or else a competent engineer having a taste for such work can in a short time become sufficiently proficient to direct the work. The remainder of the technical traffic staff may be recruited from the highway departments engineering personnel and temporarily assigned to such duty. Field work can be directed by the district or division engineers and their staffs. With practical simplified methods and proper direction, the field work or actual traffic counting can largely be performed by the regular maintenance organizations, so that no heavy increase in field payroll is necessary.

The advantage of this set-up is that the staff of the highway department becomes traffic minded. A trained organization automatically becomes available for special studies which may be needed to supplement the original survey.

By periodic counts at a relatively small number of stations using well established short cut methods, the survey can be kept up-to-date with very little expense.

What a Traffic Survey Should Develop.—A traffic survey should by all means develop the following information:

1. The total number of vehicle miles of travel per year in the state, subdivided into the volume and percentages of travel on
   (a) primary or principal state highways
   (b) county trunk or secondary highways
   (c) township or third class roads
   (d) city streets.
2. The annual saving in the operation of motor vehicles due to the use of the improved highways already available in contrast with an unimproved highway system. This will generally show that the annual savings on the improved primary system alone will be more than the annual total of motor vehicle imposts in a state.
3. The seasonal, weekly and daily fluctuations of traffic flow.
4. The composition of traffic, with percentages of the total contributed by
   (a) ordinary passenger cars
   (b) commercial vehicles
   (c) horse drawn vehicles.
5. The distribution of traffic throughout the highway system, with volumes of total traffic, truck traffic and horse drawn traffic. This information will be invaluable in determining where widening is necessary, where the type of surfacing should be improved, where highway or railway grade separations are needed as a guide to design of roads subject to equal potential traffic.
6. The distribution of truck and bus traffic by the various sizes of vehicles, so as to give actual data on size and frequency of wheel loads on various classes of highways. This data is essential for rational and economical structural design of road surfaces and structures. With such data the engineer may design for the predominating wheel loads with a safety factor of 2 and evaluate the fatigue behavior of the pavement structure under the

heavier loads as a basis for determining life expectancy.

7. The potential traffic producing characteristics (for both passenger cars and various sized commercial vehicles) for

(a) metropolitan areas
(b) industrial areas
(c) semi-industrial areas
(d) agricultural areas, on

(a) primary roads
(b) secondary or feeder roads
(c) tertiary roads
(d) city streets of various degrees of traffic importance.

8. The volume and percentage of traffic contributed by vehicles foreign to the state.

9. The traffic characteristics near metropolitan centers, embracing data on the origin and destination of traffic, traffic pressures on main thoroughfares and similar data required for intelligent metropolitan area highway planning.

10. The amount of use of city streets, primary roads, secondary roads and third class roads by

(a) residents of municipalities having
1. Population..... 0- 2,500
2. Population..... 2,500- 15,000
3. Population..... 5,000- 75,000
4. Population..... 75,000-400,000
5. Population.....greater than 400,000
(b) residents of rural areas.

When traffic information of this character has been obtained, it is essential that it be compiled in concise usuable form for administrative and engineering officials and also condensed in lucid readable form for the use of the general public. The news value of such information is enormous and well prepared news releases telling the essential parts of the story will get wide circulation.

The Economic Survey Valuable.—Another invaluable tool for the planner of highway programs is the economic survey. Such a survey should reveal the sources and distribution of highway revenues, general revenues, etc. In completed form it should answer these questions.

1. In what proportions are highway revenues of various types collected from residents of the following places?

(a) rural areas
(b) municipalities having
1. Population of..... 0- 2,500
2. Population of..... 2,500- 15,000
3. Population of..... 15,000- 75,000
4. Population of..... 75,000-400,000
5. Population of.....greater than 400,000

2. In what proportions are highway revenues of various types expended for work in the foregoing described places?

3. In consideration of the foregoing data and the data revealed by traffic surveys regarding the use of the various thoroughfares by various citizens, what distribution of these revenues will be just, economically sound and for the greatest public good?

In the initial stages of highway improvements in a given state it is obvious that the special motor imposts collected by the state should be expended by the state on a general primary highway system. However, as the primary system reaches an adequate degree of serviceability, rumblings of discontent will be heard from the cities and rural areas. These may be detected somewhat in advance of any actual need for policy change; but the wise highway administrator will give heed, proceed with traffic and economic surveys, develop the basic facts which will point out what future policies should be, and engineer the creation of a broad gauged commission on future road program whose findings and recommended policies will be available when the storm breaks. In this manner future policies may be rationally developed and translated into constructive action. Conflicting points of view, selfishness and short sightedness, when subjected to the heat of basic fact and sound reason, are soon consumed or fused into a composite, rational and equitable highway policy. Without this process, such factors may result in a highway abortion.

The economic surveys recently conducted by the United States Bureau of Public Roads in Wisconsin, Michigan and Illinois are striking illustrations of this work. They have been carried out with a thoroughness which engenders confidence and commands respect. They are invaluable, not only to the people of those states, but to highway economists, engineers and administrators everywhere. They merit careful study and reveal the type of information which is essential to the development of rational highway programs. The bureau can not be too strongly commended for having instituted these surveys and for having developed technique of performing the work. Although a veritable mass of information has been procured in them, such surveys are relatively inexpensive. The states should take advantage of the help which the bureau can give on these basic studies.

Preparation of Reports.—It is essential that complete reports of such economic surveys be published for reference and for the use of highway minded people. For general consumption, however, such texts are too bewilderingly complete. The casual reader may lose sight of salient facts or gather erroneous conclusions. Therefore it is essential, in presenting these findings to civic groups, legislative bodies, newspapers or individual citizens, that a condensed, popularized easily understood version be prepared. In fact, such a pamphlet, combining in simple attractive form the essential facts and conclusions of both the traffic and economic surveys, is absolutely essential in shaping public and legislative opinion and should be widely distributed.

Future Road Program.—At regular periods and seemingly about every 10 years, each state faces a new deal in highway affairs. Most states are now reaching a stage of highway development when clear thinking and rational planning are essential for a stabilized highway future. This situation must be met.

In accomplishing this aim the following steps will be helpful:

1. The making of traffic and economic surveys.
2. The creation by legislative authority of a broad gauged commission to study such surveys and to plan the future highway program.
3. The presentation of the findings and recommendations of this commission in a concisely written understandable report.
4. The selling of such recommendations to the public and to the legislature by means of news releases, pamphlet distribution, public meetings, etc.
5. The expression of the commission's recommendations in legislative bills.
6. The passage of the bills.
7. The translation of legislative enactments into highway accomplishment, accompanied by public confidence and popular approval.

Commission on Future Road Programs.—The commission on future road programs should be composed of broad gauged men selected from the legislative and administrative branches of government and representative citizens at large.

A commission of 17 members has proved workable. In this case five members should be selected from the state

senate, each major party being represented; five should be selected from the house of representatives, each major party being represented; five members should be citizens at large chosen for their grasp of road and general public affairs, at the same time being fairly representative of urban, rural, commercial, agricultural and geographical viewpoints; and two members, perhaps ex-officio in some cases, should be the chief administrative officer and chief engineer of the state highway department.

On first thought this commission may appear unwieldy and susceptible to such conflicting emotions as to render intelligent consideration of the problem difficult. Such has not been the case. Most of the detail work will be done by sub-committees on each of which the state highway department should be represented. The commission's final report will be prepared by a sub-committee for consideration and approval by the entire commission. After a consideration of the basic factual data heretofore described, the fair mindedness of the members will make the possibility of a minority report very remote.

A chairman should be selected who is personally popular, a good judge of character, fair minded, diplomatic and courageous. The secretary should be gifted in keeping an orderly record of the commission's deliberations and actions.

The expense of the members should be paid, but all should serve without extra compensation.

The benefits of such a membership are obvious. The legislative and civic members constitute a representative group to assist in selling the commission's recommendations to the public. The legislative members immediately become a fighting nucleus for translating the recommendations into enacted laws.

The Experience of Illinois.—The experience of Illinois in the past two years affords an interesting example of highway planning, and is recounted here as an example because of the writer's intimate knowledge of the methods used and results accomplished. For 10 years previous the state had been engaged in an intensive program of paving its primary road system of approximately ten thousand miles. The proceeds of the two state bond issues (totaling $160,000,000 and retirable from motor license fee income), the Federal aid funds, and gasoline taxes during this period were dedicated primarily to the construction and maintenance of that highway system.

When the primary system began to reach an advanced stage of completion, with excellent service afforded to most major communities, and when estimates showed that the construction of the remainder of that system could be financed with aproximately two years' revenues, the necessity for sound planning of a future program became apparent.

Conflicting and simultaneous demands for Chicago metropolitan area improvements, better street facilities in municipalities, enlargement and refinement of the primary system and improvement of secondary, county trunk or so-called farm to market roads, clearly emphasized the importance of rational planning as a means of crystallizing jumbled public opinion behind a workable and equitable program of highway development and revenue distribution.

Accordingly legislative authority was secured for the making of traffic and economic surveys and for the formation of a commission on future road program to study the highway and revenue situation and report recommendations to the general assembly when it convened in January, 1933.

Traffic and economic surveys of the character heretofore described were quickly begun and rapidly completed. Simultaneously a special cooperative traffic survey of the Chicago metropolitan area was carried on by the city of Chicago, adjacent counties, the state of Illinois and the adjacent states of Wisconsin and Indiana. A commission of the character and make-up herein recommended was formed, at a time which would afford a period of 18 months for investigation, public hearings, study of the traffic and economic surveys, formulation of recommendations and preparation of the report.

Although many conflicting opinions were held by various members of the commission in the early deliberations, the correct answer to the road problem became so apparent, after analysis of the basic facts developed by the traffic and economic surveys, that the commission's report to the general assembly in January, 1933, was unanimous.

A useful feature of the final report was a summary of conclusions and recommendations. Adjacent to each item was placed a marginal reference to the pages in the body of the report where full details could be read.

The Legislative Battle.—Subsequent to the submission of the report and the introduction of corresponding bills, some alternative programs of legislation were proposed and bills introduced. One proposal came from Chicago, another from the Illinois Municipal League, and still another from the Illinois Agricultural Association.

At this juncture, the Illinois Chamber of Commerce issued an attractive pamphlet containing a digest and discussion of pending road legislation, together with a summary of significant facts derived from the traffic and economic survey reports. This was distributed to all legislators, and to many civic bodies and individual citizens in the state. This served to clear the air. With only slight amendments to the original commission bills, the officials of the city of Chicago, the Illinois Municipal League, and the Illinois Agricultural Association were brought into agreement, the alternative programs were discarded, and, when the final test came, the commission bills were passed by both houses without a dissenting vote.

This action becomes more significant when it is realized that there was a complete change in political control of both the administrative and legislative branches of the state government, and a change in administrative officers of the state highway department at about the same time that the commission's report was submitted. Credit is due these incoming officials for their broad gauged and unbiased recognition of fundamental principles and for their support of sound legislation. Recognition is due Robert Kingery, a member of the planning commission, who subsequently became the directing head of the Department of Public Works and Buildings, and to Ernst Lieberman, Chief Highway Engineer, who contributed much toward the successful adoption of the program.

Illinois now has a modernized set of highway laws, applicable with only minor changes for at least the next decade, which are so workable and equitable, that continued popularity of the highway program is assured.

Illinois Laws Summarized.—These laws provide a definite basis of revenue distribution.

Motor License Fees

All motor license fees are reserved by the state in the following order for

(a) the payment of principal and interest on outstanding State highway bonds;
(b) the maintenance of State highways;
(c) the construction of State highways.

Division of Gasoline Tax Funds

Beginning January 1, 1934, the net proceeds of the state gasoline tax are to be allotted, one-third to the state for primary or state road construction and maintenance,

one-third to the counties for state-aid or county trunk highway construction, and one-third to municipalities for street construction and maintenance, all funds to be expended under the supervision of the State division of highways.

Basis of Allotment

The funds allotted for state primary road construction amount to one-third of the gasoline tax, and will go to the Department of Public Works and Buildings.

The allotment of funds for use by the counties as based upon the amount of motor license fees received from the residents of such counties during the preceding calendar year.

The allotment of funds for use by cities is based upon population as determined by the last preceding Federal census.

Use of Gasoline Tax Funds

(a) Funds allotted to the Department of Public Works and Buildings for primary road work (one-third of the gasoline tax) shall be used for the construction, reconstruction and maintenance of state bond issue roads, Federal aid roads, and state highway belt line roads and the maintenance of said highways in municipalities, and for the separation of grades of said state highways with railroads and with highways, and where necessary to provide adequately for traffic needs, the widening and improving of said state highways.

(b) Funds allotted to counties (one-third of the gasoline tax) shall be used for state aid road construction as in the past under the supervision of the state.

(c) Funds allotted to cities (one-third of the gasoline tax) shall be used under the supervision of the state for

1. The construction and reconstruction of state highways in municipalities.
2. The construction, reconstruction, and maintenance of a system of arterial streets or thoroughfares (other than state highways) in the municipality as may be designated by the council or president and board of trustees and approved by the Department of Public Works Buildings.
3. The construction, reconstruction, and maintenance of extensions of such arterial streets or thoroughfares outside of the corporate limits of the municipality.
4. The payment of engineering costs in connection with all such work heretofore described.
5. The payment of any municipal indebtedness which has been or may be incurred in the construction, reconstruction or maintenance of such arterial streets or thoroughfares or state highways.

Priority is given to the construction and reconstruction of state highways.

Other Legislative Features

In addition to the foregoing major policy, these laws embody many other desirable legislative features, as follows:

1. The Department of Public Works and Buildings is given authority to enter into contracts with the municipalities to perform the maintenance on streets coming under the control of the department.
2. Authority is given to construct all extensions of state highways in municipalities either with or without continuous grade separation of such width and type as may be necessary to care for traffic and parking needs.
3. The county is given the same power in constructing extensions of state-aid roads within municipalities.
4. Authority is given for the Department of Public Works and Buildings to number or renumber state highways for traffic convenience.
5. Provision is made whereby priority in the construction of state-aid roads by a county with the gasoline tax funds, shall be given to state-aid roads which join municipalities not on any state bond issue or Federal aid routes to such routes, and it is further provided that state-aid roads shall be selected for construction according to their relative importance from the standpoint of traffic needs and county-wide service, and so as to make available as rapidly as practicable continuous or connected, improved traffic routes, such selection to be by the county board with the approval of the Department of Public Works and Buildings.
6. Provision is made for a county to use money apportioned to it from the widening, reconstruction or improving of state-aid roads or extensions thereof within municipalities theretofore constructed and accepted by the state or for the widening, reconstructing or improving of state-aid roads or extensions thereof within municipalities which are coincident with improved or unimproved state bond issue or Federal-aid roads.
7. Provision is made for the orderly enlargement and rational development of the state primary road system, by means of the provisions of the Federal Highway Act. Under this legislation, when the Federal-aid road system, heretofore designated, has reached a stage of 90 per cent completion or greater, the Department of Public Works and Buildings with the approval of the United States Bureau of Public Roads may increase the Federal-aid system by adding 1 per cent of the public road mileage of the state, and when that enlarged system shall have reached a state of 90 per cent completion or greater, it may be further increased by adding 1 per cent of the public road mileage, and so on.
8. Qualifications for the office of County Superintendent of Highways are made more rigid. The method of appointment and reappointment is clarified. The salary and expenses of the County Superintendent of Highways may be paid from any county funds available for highways, and two or more counties may unite in employing the same County Superintendent of Highways.
9. Provision is made for the abolishment of present obsolete non-luminous grade crossing signs and substituting for these modern luminous protective signals, flashing signals or crossing gates which shall be illuminated at night. The Commerce Commission is given authority to divide the cost of installation and maintenance of such protective devices. The Commerce Commission is also given the authority to order the removal of obsolete car tracks and the pavings of car track areas.

Acknowledgment.—The foregoing is a paper presented at the Annual Convention of the American Association of State Highway Officials.

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Short Courses in Public Works Construction

Four new short courses, giving training in construction methods in connection with public works projects, have recently been prepared by the Extension Division of the University of Wisconsin, Madison, Wis. The four types of work covered are construction of highways, construction of sewers, construction of water supply systems, and plain concrete construction.

These courses are taught by the correspondence-study methods for men resident in any part of the country. They are described as of benefit to assistant foremen and foremen, and as having special reference to the needs of men who will be engaged in national recovery projects. A working knowledge of arithmetic is required.

The courses were prepared by the Extension department of civil and structural engineering, in charge of Prof. H. E. Pulver.

Branch Railroads and Highways

By CHARLES DAVIS,* C. E.
Founder, Trustee and President National Highways Association

MANY branch railroad lines are not earning their operating and maintenance charges, to say nothing of the interest on the investment or of profits. Some are not breaking even with operating costs. In the history of railroads many of these branch lines have only been feeders for long hauls—the really worthwhile business of the railroad.

Our highway development is played up by the railroads as the direct cause for these losses. This is mostly an error. For example, for many years Morristown, New Jersey, had a very slow growth. There were no improved highways then. These were built later. The railroad hauled most of the material used in their building. Morristown began to grow and the railroad gained part of this increase in business and did not make any actual losses. So it has been in most cases. But more than this. It is said by reliable sources that about 60 per cent of railroad business has been the result of highway building. This, of course, includes the automobile industry, garages, oil, etc., etc., as well as materials going into the construction of roads. This is something played down and sometimes concealed by the railroads.

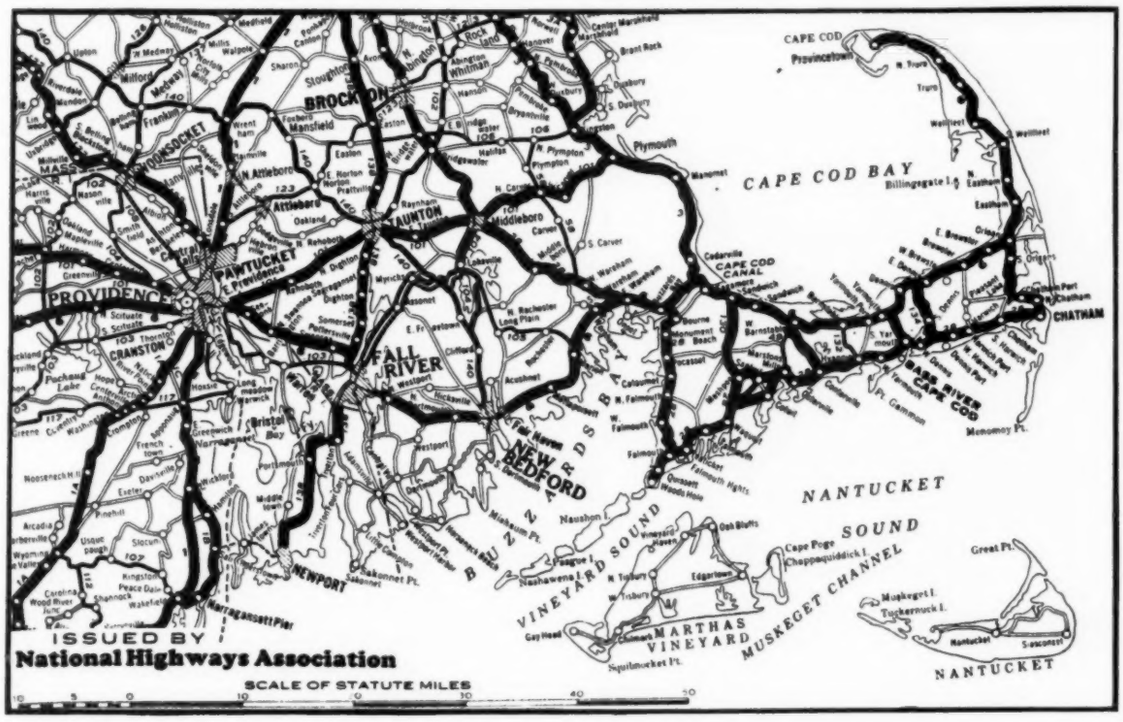
But let us assume for argument that highways are a detriment to branch railroads. In that case the answer is not to retard the building of such roads but to develop and operate them in the interest of the railroads themselves. How can this be done? Most easily! Let us see whether the way can be shown by an example. Here it is.

Forty years ago the Old Colony Railroad Company operated various lines in southeastern Massachusetts. Among them the line from Boston to Provincetown at the end of Cape Cod. At that time the Old Colony was a very prosperous property even though it had but iron rails. Later it was taken over by the New York, New Haven & Hartford Railroad. Now it no longer pays. How can it be made to pay? By building a highway close alongside of its rails. To start with: from Brockton to Provincetown through Middleboro and Buzzards Bay with two branches Middleboro to Providence, R. I., and Buzzards Bay to Woods Hole. Such a highway should be built along the following lines, namely:

1. At first a roadway 24 ft. wide one one side of the rails; this roadway to carry motor traffic in both directions. As traffic warrants, a roadway could be built on the other side of the rails when both would become two lane one-way highways.
2. Through towns or villages by-passes could be used if going through them was too costly.
3. This highway should be built under the NRA by the United States Government. The details of state, county, and town participation in the original cost, if any, can be worked out as construction progresses.
4. The railroad company should be given the exclusive right or franchise to operate motor vehicles for passenger and goods transportation for hire. The details for this can be worked out for each individual case, like any other transportation franchise.
5. All privately owned and operated motor vehicles not operated for hire by passengers or for goods would have the right to use the roadway for a suitable toll. Such tolls would continue until the roadway becomes free for such privately owned vehicles not operated for hire. The tolls and the period should vary so as to make each case self-liquidating.

The map shows the present highway development of Cape Cod and vicinity. The railroad runs between the points mentioned above through all the named places on the map. In the case of the Cape itself it runs only along the north shore, not the south shore. The highways shown as running through the same places come near the railroad tracks at some places and again recede

*Life Member and Member Legislative Committee, American Road Builders' Association; Life Member American Automobile Association; Member National County Roads Planning Commission.



Present Highway Development of Cape Cod and Vicinity

from these tracks to a considerable distance. Practically at no place is the highway alongside of and close to the railroad tracks save for a very short distance. The proposed highway should be immediately adjacent to the rails.

In this particular case, if the railroad company does not solve its problem as indicated herein, a main trunk highway will be built from Providence almost immediately east straight to Buzzards Bay and hence to Provincetown over the backbone of the Cape, as it is called. That is through the middle line of the Cape about half way from shore to shore. Such a highway would be free to all. Busses and trucks for hire and private motor vehicles would pass over it free of toll or other costs and eventually cut the railroad branch line out of everything save some long haul and heavy bulk commodities like coal.

So why not cooperate as pointed out by Alfred Adler, the great physician. Everyone would profit thereby, not the least thereof the railroad.

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20th Annual Purdue Road School

The 20th Annual Road School at Purdue University, Lafayette, Ind., will be held Jan. 22-24, under the auspices of the Engineering Extension Department and School of Civil Engineering, and in cooperation with Indiana State Highway Commission, County Surveyors' and County Engineers' Association, Highway Materials and Equipment Association, County Road Supervisors' Association and Indiana County Commissioners' Association.

Special features of the school include the following:

Smoker in Memorial Union Building, Monday night, Jan. 22. Music, entertainment, illustrated address, smokes, etc.

Road School banquet, Memorial Union Building, Thursday night, Jan. 25. Guest speakers of note.

Road Show. Exhibit of materials and equipment in Purdue Armory, Tuesday night, Jan. 23, and Wednesday afternoon and night, Jan. 24. For information relative to reservation of exhibit space, get in touch with Walter O'Neall, Secretary, Highway Materials and Equipment Association, care of W. Q. O'Neall Company, Crawfordsville, Ind.

An excellent program, including addresses by outstanding road officials and engineers from several states, has been arranged for this 20th anniversary. Two days of general sessions and one and one-half days of separate group sessions are scheduled.

Ben H. Petty is Professor of Highway Engineering at Purdue.

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Re-Numbering of Minnesota State Roads Completed

Engineers of the Minnesota Highway Department have just pieced together the state's biggest jig-saw puzzle. Handed 140 new state trunk routes covering 4,500 miles of roads, the Highway Department undertook the task of coordinating and consolidating the new mileage with 6,800 miles of the original trunk system made up of 71 state routes and 16 U. S. routes.

Out of this total of 227 different routes, the department has laid out a consolidated state trunk system of 125 routes covering 11,300 miles of highways. The result is a radically changed state highway map which will go into effect in the early spring of 1934 when the new route signs have been put in place.

In announcing completion of the renumbering plan for the enlarged trunk system, the Highway Department also announced that the entire 4,500 miles of new routes were officially taken into the state system in the last week of December. Addition of the roads to the trunk system was authorized by the regular session of the 1933 legislature, but lack of funds prevented the highway department from taking over the routes until now.

From now on the entire 11,300 miles of trunk routes will be maintained and improved by the state from the proceeds of motor vehicle license fees and the state gas tax. No real estate or personal property taxes are levied for state roads.

In renumbering the system, it was endeavored to keep the total number of routes as low as possible, to extend existing routes where practical and to eliminate the confusion caused by the former practice of having some routes carry different state and U. S. numbers. U. S. routes in the renumbered system will carry only their U. S. number, which is a great convenience to tourists and in line with national practice.

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Progressive Traffic Control for Chicago's Busiest Street

A new traffic signal system for Michigan Ave., Chicago, one of the world's busiest streets, now being installed from 12th St. to Oak St., places 30 intersections under the progressive control system. One of the innovations in the new lights will be the use of a flashing green indication informing the motorist if he is going through too fast or too slow to drive without a stop. The present average speed over the stretch is 13 miles an hour because of the numerous stops involved by the obsolete system of unsynchronized lights. Under the new plan an average speed of 24 miles per hour can be maintained throughout the two-mile stretch without any stops whatever.

Another thing new to Chicagoans will be the control of traffic going in one direction on one side of the street, absolutely independent of the control on the other side going in the other direction. Two outstanding safety features of the new lights will be the use of special signals for pedestrians only, and the shortening of the amber period before the green "Go" signal, which is to minimize the possibility of the cars starting before the cross traffic is clear.

In all the lights a special combination of reflectors and lenses will be used to give an unmistakably intense indication, eliminating confusing reflections from the sun in the late afternoon or early morning.

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Annual Meeting New England Road Builders' Association

More than 1,500 were in attendance at the 12th annual meeting of the New England Road Builders Association, held Dec. 19 at the Hotel Statler, Boston, Mass. Addresses were made by Joseph A. Tomasello, treasurer of the Association; John Coleman and Louis Perini, contractors, and others. After the dinner there was an extended, brilliant entertainment.

Those at the head table included:

Maine—Frank A. Peabody, Chairman, Maine State Highway Commission; Col. Edward E. Fransworth, Paul C. Thurston, Lucius D. Barrows.

Massachusetts—Frank E. Lyman, Commissioner, Department of Public Works; Herman A. McDonald, Arthur W. Dean, Frank F. Winsor, Benjamin R. Davis, Hon. Joseph A. Conry, Col. Thomas F. Sullivan, Robert A. Perkins, Horace Baker, Theodore A. Glynn, John H. Burke.

EDITORIALS

The Unfairness of the Stone and Gravel Producers' Code

IN our December issue we pointed out certain unfair features of the code of the crushed stone, sand and gravel industry. Since then we have met some of the spokesmen for the stationary crushing plants and they admitted that one object of the code is to curtail or prevent the use of portable crushers.

This code exemplifies the strength of an organized minority when pitted against an unorganized majority. The number of owners of portable crushers and gravel plants greatly exceeds the number of owners of stationary plants, yet the latter "wrote their own ticket" when this code was written. Even yet there is no organized opposition to the unfair features of the code.

The Associated General Contractors and the American Road Builders Association should undertake to secure a revision of the code, particularly Article VII, Section 5. State Highway Commissions should join in that undertaking, for the cost of road work will be unduly increased unless portable crushers and portable gravel plants are permitted to operate without restriction of any sort.

A stationary plant can produce stone or gravel at lower cost than a portable plant, but the cost of handling is often much higher from a stationary plant to the highway than from a portable plant. Where that is the case, and where a contractor with a portable plant can deliver stone or gravel on the highway at less than the delivered cost of a stationary plant product, no highway official should favor preventing that contractor from serving the public. Yet the code is designed to prevent just that sort of economic service in a great many instances.

The main objects of all codes are to reduce wasteful competition and to increase employment. Certainly competition is the converse of wasteful, if it results in a lower price to the public yet yields a compensatory price to the contractor. Certainly the use of portable crushers and portable gravel plants gives employment to more men than the use of stationary plants, for the latter are able to produce more cheaply because they operate with fewer men per thousand cubic yards or tons of output. Hence the code fosters both higher unit costs to the public and the employment of fewer workers.

Not only is the code unfair as written, but certain stationary plant owners are using it as a club to intimidate contractors. Let it be answered that this intimidation can not be charged against the code, still the fact remains that a code that is obviously unfair and evidently sponsored by the intimidators is bound to be regarded by the average contractor as being a thing he had better not "buck."

Perhaps it is futile at the present time to object to code provisions that are aimed to prevent plant expansions and the building of new plants. Nevertheless we must register our objection to that sort of economic policy, even as an emergency measure, when applied to an industry of the sort under consideration. The stone and gravel industry bears only a superficial resemblance to the oil industry. Both are mineral industries, but beyond that there is scarcely any resemblance. Oil deposits are limited in extent, and their ultimate depletion is in sight unless wasteful competition is halted. Stone and gravel deposits, taken as a whole, are limitless. Oil and its products can be economically transported great distances, whereas crushed stone and gravel can not. Vast investments in plant are required in the oil industry. Relatively small investments in plant will usually serve in producing stone and gravel. Considering these and other facts, a code aimed to prevent overproduction of petroleum is justified as a social measure, whereas a similar code finds little or no justification in the stone and gravel industry when carried to the point of preventing either the use of new portable crushers and portable gravel plants or the transfer of old crushers and plants to new regions.

Every highway contractor who owns a portable crusher or portable gravel plant bought it with the obvious intention of moving it to any new job that might be awarded to him. To him it never occurred that the public would deny that right. If the public can legally prevent his using his crusher or gravel plant wherever he pleases, it can legally prevent his using his motor-trucks, his graders and all his other road-building equipment. If this can be done, then the federal constitution loses all its protective power. Here again we may be uttering futilities, for the old constitution seems to have few defenders at the present time. But we shall continue to believe in the soundness and justness of that old instrument, until some one produces a better one.

Let us assume that the constitution has been scrapped, as we are justified in assuming if this code is legal; yet we believe that ethical principles have not been scrapped by the majority of Americans. So we ask: Is it ethical to forbid an owner of equipment from using it in any part of any state in the Union? This code attempts to do just that. It violates the federal constitution if it is enforceable. It ignores the Golden Rule, and it conforms to no ethical principle known to us. Had it been written by Mussolini it could not have been more dictatorial and more repugnant to men accustomed to fair dealing.

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Weather Worn

WEATHER, the time honored foe of man made schemes, interferes with his endeavors to construct permanent structures. So far as road building is concerned it is the primary destructive agent, all roads considered. Work on a road is not done when it is finally prepared to open it for traffic. It will not be long before repairs of one kind and another are required and changes deemed necessary. It is safe to say that few of the roads built 10 to 15 years ago fully meet present day requirements. The large percentage of all roads are the unsurfaced, untreated earth roads. Weather, of course, for one-third of the year, makes it impossible to use these roads. Gravel or stone improves their travelability for a considerably greater period. But no matter what the type, weather still fights against them. So maintenance is a primary consideration in road building activity.

Neglect of maintenance invites loss of investment at a rate greater than the square of the hypothetical savings of maintenance funds due to this neglect. The greatest protection to the investment is prudent expenditure of maintenance funds.

W. P. Gillette

New Equipment and Materials

New Mud-Jack

A new mud-jack for raising curb and gutter, sidewalk and street slabs has been developed by the National Equipment Corporation, Milwaukee, Wis. This is a small unit weighing less than 400 lbs. and is easily moved about the job by one man. Material required consists of a dry black top soil mixed with cement approximately 20 to 1 to take up shrinkage and set the mud. The mixture should have the consistency of thick cream or mortar. This consistency should vary, however, according to the conditions of slab, namely obstinacy of raising, end pressure, expanse of depression, and other local conditions.

The No. 10 N.E.C. Mud-Jack on the Job

The principle of operation is based upon the well known theory of hydrostatics that "pressure is exerted with equal intensity in all directions." The pressure at the 2½ in. nozzle directly below the pump is approximately 100 lbs. per square inch. The No. 10 N.E.C. Mud-Jack is equipped with a 1¼ hp. air cooled engine and has a normal capacity of approximately 1¼ cub. yds. per hour, depending entirely on the supply of materials and condition of the slab.

New Scraper Has Unique Form of Hydraulic Control

The Crescent hydraulic scraper, placed on the market last year by Sauerman Bros., Inc., 488 S. Clinton St., Chicago, features a unique form of hydraulic control which is claimed to be an improvement over previous schemes for hydraulic operation of a scraper with a tractor, and in particular is said to increase greatly the effectiveness of the scraper in penetrating hard earth materials.

The Sauerman hydraulic control provides a "crowding" action for digging, in addition to the usual dumping and holding operations of the normal hydraulic scraper. This "crowding" action requires a double acting ram and a control valve with a single operating lever having five operating positions instead of the usual three which are provided on the ordinary double acting valve. Not being able to find a hydraulic valve on the market having these five operating positions, Sauerman engineers designed a suitable valve, and this feature has since been added to standard commercial valves, as the additional operating positions are of advantage in several types of hydraulic equipment.

The central, or neutral, position permits the oil to be freely circulated by the pump and the ram to be freely moved by the weight of the scraper. Moving the lever in one direction contracts the ram, and, in the other direction, expands the ram, the first motion being used to dump the bucket and the second to "crowd" the digging action. The two "outside" positions are holding positions, which prevent travel of the ram in either direction, and, at the same time, permit free circulation of the oil by the pump.

Crescent Hydraulic Scraper, drawn by tractor, dumping strippings on spoil-pile

Because of the elliptical form of the cutting edge of a Crescent scraper, the "crowding" action raises the forward part of the cutting edge, with the result that the pull of the tractor is concentrated on a narrow portion at the back of the scraper, thereby facilitating the penetration of clay, hard-packed gravel, etc. Application has been made for patents covering these features.

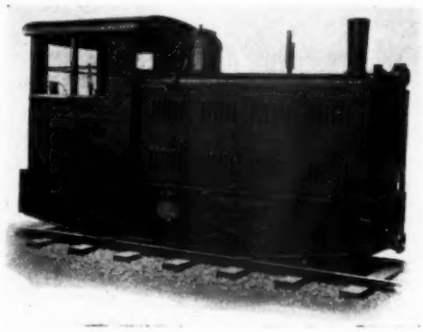
New Plymouth Diesel Locomotives

The Plymouth Locomotive Works, Plymouth, O., has brought out two new Plymouth diesel locomotives, one an 8-ton, the other a 12-ton, both of which are equipped with Caterpillar diesel engines.

The addition of these two new locomotives broadens the Plymouth line of diesels considerably. In these new locomotives is combined all of the excellent Plymouth engineering features for which Plymouth is so widely known plus the fine reputation of the Caterpillar diesel engine.

The 8-ton Plymouth Caterpillar Diesel Locomotive is powered with a 4-cylinder engine which develops 66 hp. at 850 r.p.m. The 12-ton locomotive is equipped with a 6-cylinder engine developing 102 hp. at 820 r.p.m. Thus surplus power is always available.

Considerable time has been given to the development of the new Plymouth diesels. They include every proven Plymouth engineering principle and in addition they are stated to feature for the first time, several principles that are entirely new to Locomotive design. One of the new Plymouth features is the one piece frame built of steel plates. All joints of the frame are solidly welded together and are thoroughly braced against all strains to which a locomotive is subjected. The clutch is of the dry-plate type and is ruggedly and powerfully constructed. It can be easily removed for servicing without interfering with or moving the engine or transmission.



Plymouth 12-Ton Diesel Locomotive

There are four speeds forward and four speeds reverse and all gears and shafting are constructed of special heat treated alloy steel supported on ball and roller bearings. And as in the case of all Plymouth Locomotives, a heavy duty sliding gear transmission is "standard equipment."

Best of all is the semi-elliptic cross equalized spring suspension for which Plymouth has built an enviable reputation in the locomotive field. This special type suspension, located outside the frame for easy accessibility and inspection, makes it possible for the locomotive to travel smoothly over rough and uneven tracks at full speed without danger of derailment.

Safety Flasher Signals of the Lakewood Engineering Co.

Neon illuminated flashing road signs stated to operate at a cost of only one cent per 24 hours for current are the latest development in safety signals announced by The Lakewood Engineering Co., Columbus, O., makers of Safety Neon Flashers.

The signals are entirely self contained and can be installed anywhere without

Standard signs have underground base containing battery and flasher. No concrete setting required

wiring or cables, being operated by special type Willard storage battery which provides the fixed voltage needed for signal operation for uninterrupted periods of either 6 or 15 months without adding water or recharging. This is made possible by the fact that the special battery has a shelf discharge of less than 8% in 1,000 days. A larger battery is used for the 15 month operation. Batteries are rechargeable during an estimated life of 6 to 10 years.

The safety flasher motor used in the units is of positive, clock-type mechanism, fully enclosed and insulated. According to the Lakewood Company this motor is capable of operating under all changes of temperature and humidity, in any position and under conditions of severe oscillation and vibration. Both battery and flasher are usually mounted in the base of the sign, underground, for greater safety. Where underground mounting is impractical a battery-in-head type is furnished.

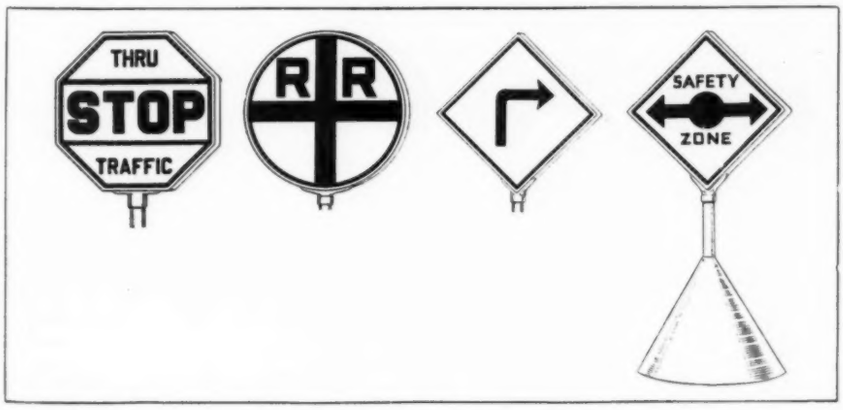
Illumination is produced by neon tubing behind cut-out letters and symbols in the cast aluminum sign face, which are shielded with shatter-proof glass.

It is pointed out that improved highways, faster motors and increase of night travel have created a real need for illuminated street and highway signs and safety zone markers which have, hitherto, been costly to install and operate by outside wiring.

Not being dependent on reflected headlamp beams the faces are mounted 7½ feet above street level where they cannot be hidden by parked or traveling cars ahead. At night the neon illuminated signal is said to be visible to approaching drivers at 1 mile and legible to the average eye at 500 feet distance.

In addition to the standard street and highway signs, the Lakewood Company also manufactures all types of built-to-order signs, safety zone markers, airport boundary lights, directional markers, hydroplane landing markers and buoys for neon illumination.

For inspection and periodic recharging of battery, hinged cover is opened with special tool which removes the vandal-proof bolts



In addition to standard faces of this type, special ornamental standards, special signs and designs of safety zone marker are built to order with Safety Neon Flasher installed

New Expansion Joint

One of the new products developed in 1933 was the expansion and contraction joint manufactured by The American Concrete Expanion Joint Company of Chicago. Known as the "Ace Joint," it attracted widespread attention because of its unique air compression construction. It was granted approval by the state of Illinois and during the year several hundred miles of highway were laid in which Ace Joints were installed.

The No. 1 Ace Joint consists of a base webb built of 26 gauge steel, crimped in the center at the bottom and flanged on both sides. A rolled strip which runs from end to end between the webb provides stiffening against collapse when pouring concrete against its sides or when tamping. At intervals of 14 in. rolled thread sockets are placed through the walls of the webb.

These provide a place into which the dowel sockets may be screwed. The upper cap is made of 16 ounce copper, has an inverted U-type construction, and has 2½-in. flanges which extend into the slabs on both sides and become bonded with the concrete through slots punched in the flanges. A premoulded bituminous strip covers and serves as a cap, providing protection during the period of insertion and assuring a straight edge line for each slab when the concrete has hardened. Thickened edge construction, as specified in some states, is provided for by a shoe which slides on the ends of the joint. A cap for the ends is provided by means of a plate fastened in a slot in the metal walls of the webb. A sliding plate is placed on the bottom of the thickened edge shoe and is pushed under the con-

You Should about Paving

Know the Facts Asphalt Cement

STANOLIND Paving Asphalt Cement is not simply an asphalt but an asphalt cement whose high qualities are controlled by careful manufacturing and skillful supervision.

Stanolind has the highest of cementing qualities. It meets all recognized standard specifications and requirements for consistency at atmospheric temperatures.

At the proper working temperature, paving mixtures made with Stanolind Paving Asphalt mix readily and are easy to spread to a smooth surface.

The superior qualities of Stanolind Paving Asphalt, such as cementing value, viscosity, and uniformity, are important factors in securing pavements of highest quality with smooth, easy riding surfaces.

Investigate the facts concerning paving asphalt cement if you want the best paving per dollar of cost.

123-C

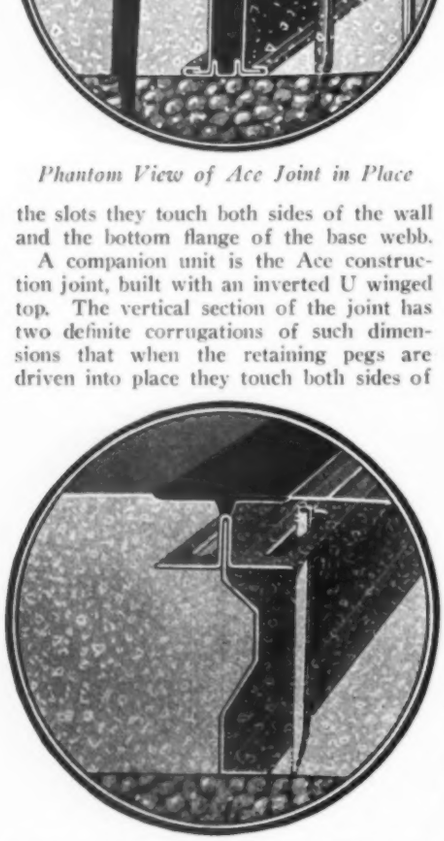
STANDARD OIL COMPANY
(INDIANA)
910 S. MICHIGAN AVE. CHICAGO, ILLINOIS

struction curb wall at each end of the joint. This joint has sufficient flexibility to assume a road crown of 1½ in. without any degree of distortion. Vertical position of the joint is assured because when pegs or road pins are vertically driven through

Phantom View of Ace Joint in Place

the slots they touch both sides of the wall and the bottom flange of the base webb.

A companion unit is the Ace construction joint, built with an inverted U winged top. The vertical section of the joint has two definite corrugations of such dimensions that when the retaining pegs are driven into place they touch both sides of



Cross Section of Longitudinal Construction Joint and the Transverse Construction Joint, Minus Thickened Edge Shoe of the Latter.

the slot and the outer edges of the corrugations on each side. Holes for dowel bar insertion are provided as specified. Placement of this joint in a straight line is assured by a recessing of the wing tops in such a manner as to guarantee a positive accurate fitting of one into the other.

With both joints positive protection against seepage of water through the joint is provided by the winged type construction.

▼

An Improved Black Top Paver!

An improved black top paver has been announced by the Adnun Engineering and Manufacturing Co., Nunda, N. Y.

The paver is self-propelled and rolls on the sub-grade and finished course. It consists of a hopper mounted on a sturdy frame carrying an operating platform, engine, and attending mechanism. The front end is supported by two wheels that are engine-driven and steered from the platform. The rear end is mounted on four rollers also powered and controlled for steering.

The truckload of material is backed between the front wheels and dumped to the hopper. An agitator bar at the bottom of the hopper draws the material down to the grade where it is cut off by a moving cutter bar similar to that of a mower.

An initial compression of the pavement is secured by the beveling of the underside of the cutter bar teeth. The machine lays pavement of any width and any thickness. It requires no forms, needs no preparation of shoulders, and will lay pavement right up to the road edge.

Adnun Black Top Paver.

It has been used on practically every type of black top pavement, both hot and cold, and has demonstrated its ability to handle stiff mixes that have been standing and become lumpy, using lumps and all.

The peculiar action of the cutter bar strike-off makes it possible to lay an accurate abutting joint in laying parallel courses or in laying up to line of curb without raking or hand work.

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New 1¾-Yd. Shovel

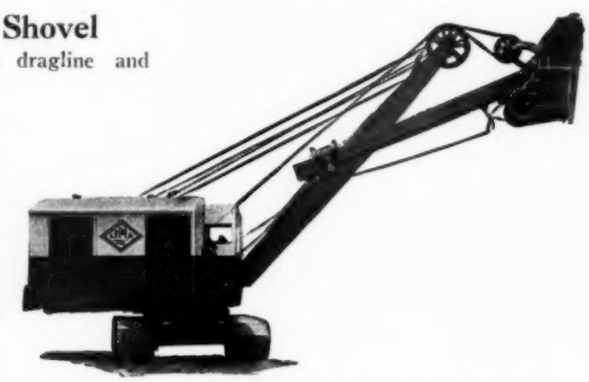
A new 1¾-yd. shovel, dragline and crane has just been announced by The Ohio Power Shovel Company, Lima, O. This new machine has been designated as the Type 701.

It is powered by a 6-cylinder gasoline engine. Provision is made, however, for installing Diesel or electric power units when desired. Special attention has been given to the selection of materials. Every shaft, etc., is made of a steel specially formulated for its particular use. Noisy spur gears are discarded for the quiet long-lived helical cut type. Friction is practically eliminated by the use of roller bearings at every vital bearing point.

Other advantages found in the Type 701 consist of square lever shafts which eliminate troublesome keys. Shafts on which are mounted sliding members are splined for accuracy in fit and elimination of backlash. Cable life is greatly lengthened by the use of drums with exceptionally large diameters. Each drum is of sufficient diameter to accommodate extra long cables without double wrapping.

Synchro-power clutches insure ease of operation by responding smoothly to the slightest motion of the control levers. All major motions are independent, therefore making it possible to hoist, travel, swing, steer, and raise or lower the boom simultaneously.

The boom and dipper handle are of box type construction which insures great strength and durability. The manganese dipper is cast in one piece with detachable lip. The crawler truck is the open roller type with provisions made for applying extensions in the field whenever greater bearing surface is required. The machine is easily and quickly converted into various combinations by simply changing front end equipment.



New 1¼-yd. Shovel of Ohio Power Shovel Co., Lima, O., Is Powered by a 6-Cylinder Engine, but Provision Is Made for Installing Diesel or Electric Power Units, if Desired.